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X

ADDITIONAL OBSERVATIONS

ON THE

PROPORTION OF REAL ACID

IN

THE THREE ANTIENT KNOWN MINERAL ACIDS,

AND ON

THE INGREDIENTS IN VARIOUS NEUTRAL SALTS,
AND OTHER COMPOUNDS.

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THE fundamental experiments on which the proportion of real acid in the three mineral acids antiently known, and also the proportion of ingredients in many neutral salts, were determined, I have already set forth in a paper to be found in the IVth Vol. of the Transactions of this Academy. In that paper I have inserted tables of the quantity of standard acid existing in 100 parts of each of the acid liquors, of given specific gravities, and also in each of the neutral salts therein mentioned; the mode of expressing the quantity of acid I had then adopted I since discovered to be very inconvenient, as in some of these neutral salts an acid still stronger than the assumed standard was found to exist. But I have there also noticed that the strongest vitriolic acid now known, existed in *vitriolated tartarin*, the strongest nitrous acid in *nitrated soda*, and the strongest muriatic acid in *muriated tartarin*;

Acids of such strength I have therefore denominated *real*, as either containing no water or containing only as much as is necessary to their essential composition, as far as this is at present known. The method of transforming the expression *standard* into that of *real*, I have there also given p. 67, and by it have formed the table I here present; this latter expression I therefore now employ in every case instead of that of *standard*, together with the substitution of a more commodious expression of the strength of acids: The design of this paper is also to exhibit an illustration or amendment of several of the determinations contained in my last, which being for the most part single, required confirmation by shewing their agreement with the experiments of several of the most eminent chymists made since the publication of mine, that is since the year 1791, with a few made nearly at the same time. In my former paper I compared my results with those of Bergman and Wenzel, they being almost the only persons who had made this subject the principal object of their enquiry, and had pursued it to a considerable extent; in each particular instance I have traced the reason of the difference of their results from my own when it was such as to deserve notice, and I shall not here repeat what I have there said; but I cannot avoid again mentioning one general source of error attending the mode of investigation adopted by both and yet noticed by neither, namely the loss that many neutral salts undergo during evaporation, a loss whose discovery is of considerable importance, not only to the present inquiry, but also to the



the conduct of several manufactures, particularly to that of saltpetre, and hence noticed by Mr. Lavoisier, 15 An. Chy. 254. On this head however I hope the Academy will soon receive the fullest information, as our worthy member, Mr. Higgins, has at my request undertaken to examine its reality and extent with respect to a considerable number of the most known among these salts.

THOUGH Bergman and Wenzel should have conducted their experiments nearly in the same manner, as far as we can judge from the mode prescribed by Mr. Bergman in his notes on Scheffer, published in 1779, yet his results differ considerably in many instances from those of Wenzel, and appear to me far more faulty, the cause of which seems to me to be, that he has in most cases departed from the method he had originally proposed to follow, and supposed quantities of water of crystallization to exist in various substances without sufficient reason, or at least without assigning any such. Thus he tells us that pellucid calcareous spars lose only 34 per cent. of fixed air by solution in acids, whereas the daily experience of all chymists shews them to lose from 43 to 44 per cent. but 11 of these he supposes to be water, because by distillation he could not obtain more than 34 per cent. of fixed air, a method now well known to be defective, as from the porosity of earthen retorts, the inefficacy of lutes, and the insufficiency of the heat applicable to those of glass, the true quantity of fixed air can never be thus obtained. Mr. Cavendish could obtain from 311 grains
of

of Carrara marble only 1 grain of water*, and Florian de Bellevue, who lately has particularly enquired into this matter, says, marbles contain no water, or scarce any; and it is of the granularly crystallized that he speaks†. Dr. Watson also makes the same remark.

To tartar vitriolate Bergman has also assigned 8 grains of water of crystallization, whereas when dried even in a heat of 70 degrees only, except it contains an excess of acid, it retains not even 1 per cent. of water. To nitre he assigns even 18 per cent. a quantity so great that he can scarce be supposed to have meant water of crystallization. Lavosier, who by profession must have been well acquainted with a property so obvious, tells us on the contrary that it contains little or none, 15 An. Chy. 256. Mr. Keir allows it when not well dried about 2,5 per cent. Wenzel, on the other hand, took but little notice of the water of crystallization, and his mistakes are not so considerable, most of them independently of the source of error already mentioned originated from the supposition of a fictitious substance which he called *Causiticum*, the unheeded decomposition of nitre when strongly ignited, and the supposition that acids, when the compounds into which they enter are heated to redness, either retain no water or at least a constant and not a variable quantity of it; this is indeed an error inherent in the method pursued by him,

Bergman

* Phil. Trans. 1766, p. 167.

† 41 Roz. 94.

Bergman and myself in my first essays. But he also followed another method, which preserved him from many mistakes, which was to estimate the quantity of the strongest acid in a given quantity of vitriolic acid, $v : z : 240$ grains by the quantity of it retained during ignition in tartar of vitriolate, and in 240 grains muriatic acid by the quantity retained in muriated tartarin, for in effect these acids, as I have found, contain least water in these compounds; this advantage however he sometimes lost by the decompositions arising from ignition, particularly in his experiments on metallic substances.

To render this paper still more useful, I shall lay before the Academy some important determinations of the proportion of ingredients in compounds of which I had not myself treated, and are either not generally known, or scattered in divers treatises not easily collected, to most of which however I have added my own experiments.

WHEN alkalies or earths combined with fixed air are dissolved in acids, though far the greater part of the fixed air is expelled during the solution, yet some portion of it is often retained, and may in some degree alter the sp. grav. of the solution; this circumstance I did not recollect till lately; it was first noticed by Mr. Cavendish, Phil. Transf. 1766, p. 172, and afterwards by Bergman in his notes on Scheffer, §. 51, but more explicitly by Scheele, Chy. An. 1786,

p. 13, and by Butini on Magnesia, p. 149. As to the use resulting from researches of this nature it were superfluous to attempt to prove it at this day, the recourse which the most eminent analysts have been obliged to have to it in particular instances, as will presently appear, sufficiently evinces it. "Inquiries of this kind (says " Mr. Fourcroy) are more difficult and delicate than those which " have hitherto been made on salts; whatever requires a precise " knowledge of quantities and proportions, presents difficulties so " great as often to appear insurmountable, yet without this know- " ledge no progress can now be made in chymistry," 10 An. Chy. 325; and according to Bergman, " *Ufus cognitæ proportionis prin- " cipiorum ingredientium egregius est et multifarius.*" 1 Bergm. 137. chap. 1. § 1.

TABLE

T A B L E

O F T H E

Q U A N T I T Y O F R E A L A C I D

In 100 Parts of Vitriolic, Nitrous and Marine Acid Liquors of different Densities, at the Temperature of 60°.

In Vitriolic Acid of different Densities, at the Temperature of 60°.				In Nitrous Acid of different Densities, at the Temperature of 60°.				In Marine Acid of different Densities, at the Temperature of 60°.	
100 Parts Sp. Gravity.	Real Acid.	100 Parts Sp. Gravity.	Real Acid.	100 Parts Sp. Gravity.	Real Acid.	100 Parts Sp. Gravity.	Real Acid.	100 Parts Sp. Gravity.	Real Acid.
2,0000	89,29	1,4666	44,64	1,5543	73,54	1,3364	41,91	1,196	25,28
1,9859	88,39	1,4427	43,75	1,5295	69,86	1,3315	41,18	1,191	24,76
1,9719	87,50	1,4189	42,86+	1,5183	69,12	1,3264	40,44	1,187	24,25
1,9579	86,61	1,4099	41,96	1,5070	68,39	1,3212	39,71	1,183	23,73
1,9439	85,71	1,4010	41,07	1,4957	67,65	1,3160	38,97	1,179	23,22
1,9299	84,82	1,3875	40,18	1,4844	66,92	1,3108	38,34	1,175	22,70
1,9168	83,93	1,3768*	39,28	1,4731	66,18	1,3056	37,50	1,171	22,18
1,9041	83,04+	1,3663	38,39	1,4719	65,45	1,3004	36,77	1,167	21,67
1,8914	82,14	1,3586	37,50	1,4707	64,71	1,2911	36,03	1,163	21,15
1,8787	81,25	1,3473	36,60	1,4695	63,98+	1,2812	35,30+	1,159	20,64
1,8660	80,36	1,3360	35,71	1,4683	63,24	1,2795	34,56	1,155	20,12
1,8542	79,46	1,3254	34,82	1,4671	62,51	1,2779	33,82	1,151	19,60
1,8424	78,57	1,3149	33,93	1,4640	61,77	1,2687	33,09	1,147	19,09
1,8306	77,68	1,3102	33,03	1,4611	61,03	1,2586	32,35	1,1414	18,57
1,8188	76,79+	1,3056	32,14	1,4582	60,30	1,2500	31,62	1,1396	18,06
1,8070	75,89	1,2951	31,25	1,4553	59,56	1,2464	30,88	1,1358	17,54
1,7959	75,—	1,2847	30,35	1,4524	58,83	1,2419	30,15	1,1320	17,02
1,7849	74,11	1,2757	29,46	1,4471	58,09	1,2374	29,41	1,1282	16,51
1,7738	73,22	1,2668	28,57	1,4422	57,36	1,2291	28,68	1,1244	15,99
1,7629	72,32	1,2589	27,68+	1,4373	56,62	1,2209	27,94	1,1206	15,48
1,7519	71,43	1,2510	26,78	1,4324	55,89	1,2180	27,21+	1,1168	14,96
1,7416	70,54+	1,2415	25,89	1,4275	55,15	1,2152	26,47	1,1120	14,44
1,7312	69,64	1,2320	25,—	1,4222	54,12+	1,2033	25,74+	1,1078	13,93
1,7208	68,75	1,2210	24,10	1,4171	53,68	1,2015	25,00	1,1036	13,41
1,7104	67,86	1,2101	23,21	1,4120	52,94	1,1963	24,26	1,0984	12,90
1,7000	66,96	1,2009	22,32	1,4069	52,21	1,1911	23,53	1,0942	12,38
1,6899	66,07	1,1918	21,43+	1,4018	51,47	1,1845	22,79	1,0910	11,86
1,6800	65,18	1,1836	20,53	1,3975	50,74	1,1779	22,06	1,0868	11,35
1,6701	64,28	1,1746	19,64	1,3925	50,00	1,1704	21,32	1,0826	10,83
1,6602	63,39	1,1678	18,75	1,3875	49,27	1,1639	20,59	1,0784	10,32
1,6503	62,50	1,1614	17,85	1,3825	48,53	1,1581	19,85	1,0742	9,80
1,6407	61,61	1,1531	16,96	1,3775	47,80	1,1524	19,12	1,0630	8,25
1,6312	60,71	1,1398	16,07	1,3721	47,06	1,1421	18,48	1,0345	5,16
1,6217	59,82	1,1309	15,18+	1,3671	46,33	1,1319	17,65+	1,0169	2,58
1,6122	58,93	1,1208	14,28	1,3621	45,59	1,1284	16,91		
1,6027	58,03	1,1129	13,39	1,3571	44,86+	1,1241	16,17		
1,5932	57,14	1,1011	12,50	1,3521	44,12	1,1165	15,44		
1,5840	56,25	1,0955	11,60	1,3468	43,38	1,1111	14,70		
1,5748	55,36+	1,0896	10,71	1,3417	42,65	1,1040	13,27		
1,5656	54,46	1,0833	9,80						
1,5564	53,57	1,0780	8,93+						
1,5473	52,68	1,0725	8,03						
1,5385	51,78	1,0666	7,14						
1,5292	50,89	1,0610	6,25						
1,5202	50,00	1,0555	5,35						
1,5112	49,11+	1,0492	4,46						
1,5022	48,21	1,0450	3,57						
1,4933	47,32	1,0396	2,67						
1,4844	46,43	1,0343	1,78						
1,4755	45,53								

* The Sp. Gravity was 1,3741 in the former Table.

The Numbers above the Lines drawn across the Tables of vitriolic and nitrous Acids were found by Experiments; those under the Lines only by Analogy.

The Affinity of vitriolic Acid to Water decreases in the Ratio of the Square of the Quantity of Water united to it. 23 Ann. Chy. 196 and 197.

And so I believe it does to all other Substances; it is the *mean* Affinity that is commonly given.

Note. The standard Quantities of Vitriolic Acid were reduced to *Real* by multiplying them into 0,8929. of the Nitrous, by multiplying them into 0,7354, and the Marine by multiplying them into 0,516, for the Reasons mentioned in my last Paper.

Of the Alteration arising from Difference of Temperature.

To discover this alteration by experiment in each individual instance would be an endless task, hence I have selected only 3 cases with respect to the vitriolic acid, and 2 of the nitrous, and observed the changes in each at every 5 degrees above 60° unto temperature 70°, and at every 5 degrees below 60° unto temperature 50° nearly, these being the temperatures at which experiments are usually made.

Of the Vitriolic Acid.

Vitriolic acid	1,8360	at temperature	60°
Becomes	1,8292	at	- 70°
	1,8317	at	- 65°
	1,8382	at	- 55°
	1,8403	at	- 50°
	1,8403	at	- 49°

hence we see that vitriolic acid, whose density at 60° is 1,8360, loses by *ascending* and gains by *descending* 0,00068 for every degree of temperature between 60° and 70° and 0,00043 nearly by each degree between 60° and 49°.

B

Again

Again, vitriolic acid	1,7005	at	-	60°
Becomes	1,6969	at	-	70°
	1,6983	at	-	65°
	1,7037	at	-	55°
	1,7062	at	-	50°

hence vitriolic acid, which at 60° is 1,7005 gains or loses 0,00036 nearly for every degree between 60° and 70°, and 0,00051 by every degree between 60° and 50°.

Lastly, vitriolic acid	1,3888	at	-	60°
Becomes	1,3845	at	-	70°
	1,3866	at	-	65°
	1,3898	at	-	55°
	1,3926	at	-	49°

hence vitriolic acid, which at 60° is 1,3888 gains or loses 0,00043 nearly by every degree between 60° and 70°, and 0,00034 nearly by every degree between 49° and 60°, between 49° and 50°, I perceived no difference.

Of the Alteration of Density from Difference of Temperature in Nitrous Acid.

Nitrous acid, which was	1,4279	at	-	60°
Became	1,4178	at	-	70°
	1,4225	at	-	65°

1,4304

[11]

1,4304	at	-	55°
1,4336	at	-	50°
1,4357	at	-	45°

hence nitrous acid, which at 60° is 1,4279, gains or loses 0,00101 nearly by every degree between 60° and 70°; and 0,00052 by every degree between 45° and 60°.

I formerly found that the strongest *spirit of nitre* is most expanded by heat or contracted by cold.

Also, that nitrous acid, whose sp. grav. at 34° was 1,4750, was expanded by heat as follows :

1,4750	at	34°	} then it gains or loses 0,0097 by 15° between 34° and 49° inclusively.
became 1,4653	at	49°	

Again I found that colourless nitrous acid whose sp. grav. was

	1,4650	at	-	30°
became	-	1,4587	at	- 46°
	1,4302	at	-	86°

hence by the first 16° from 30° to 46° it gained 0,0063, and by 40°, that is from 46 to 86°, it gained 0,0285.

Again, nitrous acid whose density was

	1,2363	at	-	60°
became	-	1,2320	at	- 70°
	1,2342	at	-	65°

B 2

1,2384

[12]

1,2384	at	-	55°
1,2406	at	-	50°
1,2417	at	-	45°

hence nitrous acid, which at 60° is 1,2363, gains or loses by every degree between 60° and 70°, 0,00043 and 0,00036 by every degree between 60° and 45°; and we may assume 0,0005 as the variation incident to every degree between 60° and 70° in nitrous acid, whose density at 60° is between 1,3 and 1,4 and 0,0004 for the variation between 44° and 60°

Of Marine Acid.

I formerly found that this acid of the density 1,196 at 33° became of the density 1,1820 at 66°, the alterations of acids of lower sp. grav. I have not examined, but I found that in general its dilatibility is greater than that of nitrous acid of the same density.

OF THE USE OF THESE TABLES.

PROBLEM 1st.

AN *extratabular* specific gravity being given, but intermediate between some of those in the table, to *find the quantity of real acid* in 100 parts of such acid liquor.

1st.

1st. FIND the difference betwixt the next higher and lower tabular densities = D , and also the difference betwixt their acid contents = D' .

2d. FIND the difference betwixt the *extratabular* sp. gravity and the next upper or next lower, which ever it is nearest to = d , and let the difference betwixt its acid contents (or quantity of real acid) and those of the next upper or lower = d' , which is the quantity sought; then as $D. D' :: d. d'$ then $d' = \frac{D' d}{D}$ consequently d' added to the acid contents of the lower tabular sp. grav. or subtracted from the upper, *is the quantity sought*.

Note. IN general when d , that is the difference between the extratabular sp. grav. and any tabular sp. grav. does not exceed $\frac{2}{1000}$ it is insensible, and the acid contents of the lower or upper, which ever is nearest, may be ascribed to it.

PROBLEM 2d.

THE *quantity of real acid* in 100 parts of an acid liquor being given but *extratabular*, being intermediate between some of the quantities in the tables, *to find the sp. grav. of such acid liquor*.

FIND D, D' and d as in the foregoing problem. then $d = \frac{D d'}{D'}$ then d added to the lower tabular sp. grav. or subtracted from the upper, gives the sp. grav. sought.

BUT

BUT with regard to the *marine acid* its sp. grav. is to be investigated according to the ordinary mathematical rules.

PROBLEM 3d.

To find how much water must be added to 100 parts of an acid liquor of a given sp. grav. to bring it down to another lower given sp. grav.

1st. FIND by the table the quantities of acid and water in 100 parts of each of the acid liquors respectively, each being supposed to be in the table, let the quantity of water in the denser be W , and the quantity of acid = A , let the quantity of water in the less dense = w , and the quantity of acid = a , and the quantity of water to be added to 100 parts of the denser = m

then $W + m$ must be to A as w to a

And $W a + a m = A w$. And $a m = A w - W a$.

$$\text{And } m = \frac{A w - W a}{a}$$

PROBLEM 4th.

GIVEN weights of 2 or more acid liquors of different sp. gravities being mixed, to find the quantity of real acid in 100 parts of the mixt liquor and its sp. grav.

FIND

FIND the sum of the quantities of real acid in 100 parts of the mixture, then find the resulting sp. grav. by the 2d problem, if the given sp. gravities be extratabular, the operation must be more tedious, as the acid contents of each must be found.

PROBLEM 5th.

THE quantity of an acid liquor requisite to saturate 100 *parts* of *any basis* being found, to find the sp. grav. of that acid liquor.

1st. FIND by the 4th table the quantity of real acid requisite to saturate 100 *parts* of the given basis, it is then plain that the *given* quantity of acid liquor contains the requisite quantity of *real acid*, since it is supposed to saturate 100 parts of the basis and hence we may see how much 100 parts of such acid liquor contains of *real acid*, and if this last found quantity be in the table, its sp. grav. will be seen, but if extratabular, its sp. grav. must be sought by the 2d problem.

PROBLEM 6th.

THE quantity of real acid requisite to saturate 100 parts of any basis being known, to find how much of one acid liquor of any given sp. grav. is requisite to saturate that, and consequently any other given quantity of such basis.

If

If the given sp. grav. of the acid liquor be *tabular* the quantity of real acid in 100 parts of it is apparent, and consequently the quantity of such acid liquor containing the required quantity of real acid, is easily found by the rule of proportion. But if the given sp. grav. is *extratabular* the quantity of real acid in 100 parts of the acid liquor must be sought by the first problem.

PROBLEM 7th.

THE quantity of real acid, in a given quantity of an acid liquor being known, and also the quantity requisite to saturate 100 parts of any given basis. To discover the quantity of such basis contained in any solution, or in any powder, by which the given quantity of acid liquor is saturated.

If the basis be single (that is unmixed with any other basis to which the acid may unite) or combined only with fixed air the solution is easy, but if the given bases be mixed with other bases combinable with the same acid, the solution is more complex and varies according to the variety of cases.

PROBLEM 8th.

To find how much of an acid liquor of *one sort* will hold as much *real acid*, as is held by a given weight of an acid liquor of *another sort* whose sp. grav. is also given:—For instance, how much vitriolic acid will contain the same quantity of real acid as is contained in 100 grains nitric acid whose sp. grav. is 1,3925.

1st.

1st. First find by the table the quantity of real acid contained in the given quantity of the second acid, whose sp. gr. is given, or if not in the table it must be found by Problem 1st.

2d. It is apparent that the quantity of the first acid liquor must vary with its sp. gr. thus, in the instance given, as 100 parts nitrous acid of the sp. grav. 1392 contains 50 parts real nitrous acid, so 100 parts vitriolic acid whose sp. grav. is 1,5202 contains by the table the same quantity of real acid, *v. z.* 50 parts, but of the vitriolic acid whose sp. grav. is 1,800 only 64 parts are requisite to contain 50 parts of real acid, whereas 200 grains are requisite of the vitriolic acid whose sp. grav. is 1,2320.

Note, The solution of this problem may hereafter be found of use in comparing the quantities and affinities of oxygen in different acids.

PROBLEM 9th.

To find the sp. grav. of such vitriolic acid as that 100 parts of it shall contain the same quantity of real acid as 100 parts of the nitrous.

THIS can be found only by *inspection* on consulting the tables; an example has been seen in the last problem, so also 100 parts vitriolic acid 1,3102 contain the same quantity of real acid as 100 parts nitrous acid whose sp. gr. is 1,2687. And 100 grains vitriolic acid whose sp. gr. is 1,1746 contains the

C

same

same quantity of real acid as 100 grains sp. salt whose sp. gr. is 1,159.

AND 100 grains nitrous acid 1,1963 contains the same quantity of real acid as 100 grains spirit of salt whose sp. grav. is 1,187.

HENCE it should seem that the sp. grav. of the *real marine acid* is smaller than that of the *real nitrous*, and that of the real nitrous smaller than that of the *real vitriolic*, since when the weight of each acid, and also the weight of real acid in each is equal, the vitriolic acid is specifically heavier than the nitrous, and the nitrous than the marine, but this perhaps may arise from penetration.

PROBLEM 10.

To find how much of a neutral salt of one sort holds as much real acid or basis as a given weight of the *same* neutral salt in another state, or as a given weight of *another* salt in any given state.

THESE questions are resolved by the 4th and 5th tables, thus if it be asked, how much nitre contains as much acid as 20 grains of vitriolated tartarin? By the 4th table I see that 221,48 parts of vitriolated tartarin and 227,22 parts nitre contain equal quantities of acid since both contain 100 parts, then as 221,48. 227,22 :: 20.20,5.

AGAIN,

AGAIN, How much deficcated soda will hold as much alkali as 30 parts crystallized soda? In the 5th table I see that 541,1 parts of the crystallized hold as much alkali as 227,4 parts of the deficcated, then as $541,1 : 227,4 :: 30 : 12,6$.

PROBLEM 11th.

How much of a given basis will be requisite to saturate the acid contained in a given quantity of a given neutral salt, thus how much deficcated soda will be requisite to saturate the acid contained in 50 parts crystallized Epsom?

By the 4th table I see that 100 parts real vitriolic acid are contained in 340 parts crystallized Epsom. Then if $340 : 100 :: 50 : 14,7$, then by the 3d table I see that 100 grains of real vitriolic acid saturate 78,32 of soda. Consequently if 100 saturate 78,32 :: 14,7 would saturate 11,51 of soda.

Lastly, In the 6th table I find that 100 grains deficcated soda contains 60 of soda. Then if $100 : 60 :: x : 11,51$, then $x = 19,1$ parts deficcated soda. Then 19,1 parts deficcated soda will saturate the acid contained in 50 parts crystallized Epsom.

Note 1st. This problem is of use in determining the quantity of any precipitating substances to be employed in decompositions,

operated either by a single or double affinity. But in most cases *more* of the precipitant must be employed than the exact quantity necessary for saturation, and particularly when decompositions are attempted in the dry way, as otherwise a complete contact with the substance to be decomposed will not be attained, or if volatile it may be sublimed before the decomposition takes place.

PROBLEM 12th.

SOME analysts have denoted the strength of their acids by expressing the quantities of each necessary to saturate a *certain quantity* of alkaline liquor (and sometimes of another basis) without even telling whether the alkali was mild or caustic, or the quantity of it contained in the alkaline liquor. This problem is consequently indeterminate. However a method of giving some solutions of it may be understood from the following example; and circumstances will generally shew whether the application to particular cases be just.

Link tells us that 240 grains of a vitriolic acid which he employed, saturated 6,5 times its weight of tartarin (he must mean in a liquid state, as no vitriolic acid will saturate six times its weight of real alkali) and that 240 grains of the nitrous acid he employed saturated 2,5 times its weight of the same alkali. *Quere* the specific gravity of both acids?

If it is plain, that since 240 grs. of the nitrous acid saturated 2,5 times its weight of the alkali, 624 grs. of that acid would saturate

turate 6,5 times its weight of the alkali; and since 624 grs. of the nitrous acid would saturate as much alkali as 240 of the vitriolic acid, then 260 grs. of it would saturate as much alkali as 100 grs. of the vitriolic acid could saturate. Therefore supposing 100 of the vitriolic acid to contain 75 of real acid, since more real nitrous acid is required to saturate a given quantity of tartarin than of vitriolic acid, in the inverse ratio of 1214 to 1177 (as appears by the third table,) then denoting the quantity of real nitrous acid in 260 grs. of the nitrous liquor, by x we have the following equation as 1214. 1177 :: x 75. and $x = 77,55$. Then 260 grs. of the nitrous acid contain 77,55 of real nitrous acid, consequently 100 grs. of it contained 29,82 real acid. And therefore its sp. grav. was nearly 1,234, and that of the vitriolic about 1,800.—The quantity of alkali in the alkaline liquor might also on this supposition be determined.

So if it be required to know how much common salt is requisite to decompose a solution of nitrated silver containing 176,25 grs. of silver:

1st. I find by the 6th table that 75 grs. silver take 16,54 of marine acid, consequently 176,25 gr. silver take up 38,87.

2d. By the 4th table, I find that 100 grs. muriatic acid are contained in 257,2 of common salt, consequently 38,87 are contained in 99,973, that is 100 grs. common salt, then 100 grs. of it are necessary to precipitate the silver.

ILLUSTRATION

ILLUSTRATION OF THE TABLES.

FEW chymists have made experiments apposite to my present purpose, and those that have made any relative to it, have generally neglected marking the temperature, and thus prevented an exact comparison of the results they obtained with those that should be expected from the quantities of real acid and water set forth in my tables.

THE most accurate of these experimenters was Hahn, who has instituted a considerable number, of which an account is given in his Dissertation *De Efficacia Mixtionis in Mutandis Corporum Voluminibus*; of these I shall select a few, which I think by their coincidence with the results to be obtained, calculating from my tables, furnish a full proof of their accuracy, at least to as great a degree as can be expected in subjects of this nature.

OF THE TABLE OF VITRIOLIC ACID.

1st Experiment.

HAHN, to 800 grs. of vitriolic acid whose sp. grav. was 1,8489 at the temperature of 44°, added 400 grs. of water in a vessel that confined the vapours, and when the mixture was cooled down to the temperature of the air he found its sp. grav. 1,545.—p. 48 and 49.

Application.

Application.

VITRIOLIC acid of this density loses, as we have seen, ,00043 in density, by each degree between 44° and 60° ; hence its sp. grav. at 60° should be $1,8489 - ,00043 \times 16 = 0,0068 = 1,8421$, which differs insensibly from the next lower tabular sp. grav. $1,8424$, and therefore this may be taken for it.

THE quantity of real acid in 100 grs. of the acid liquor, whose sp. grav. is $1,8424$ amounts to $78,57$ per cent. *per table*, then 800 grs. of that acid liquor contains $78,57 \times 8 = 628,56$ of real acid, and consequently the 1200 gr. of the mixture contain that quantity of real acid, and therefore 100 grs. of the mixed liquor contain $52,38$ of real acid, which we see differs but little from the *tabular real acid*, $52,68$ which indicates the sp. grav. to be $1,5473$, and the difference between this and the sp. grav. found by Hahn is inconsiderable.

HOWEVER, to obtain a closer approximation, and to give an example of the mode of solving the 2d problem, I shall deduce the sp. grav. from the rules laid down for the solution of that problem.

1st. THE next higher sp. grav. is $1,5473$, and the next lower is $1,5385$, and the difference between them is $0,0088 = D$. Their acid contents are $52,68$ and $51,78$, and their difference $0,9 = D'$.

2d.

2d. THE difference betwixt the given extratabular acid contents, 52,38, and the next lower tabular acid contents 51,78 is $0,6 = d'$ then d , the quantity to be added to the lower sp. grav. is found by the formula $d = \frac{D d'}{D'} = \frac{0,0088 \times 0,6}{0,9} = \frac{0,0528}{0,9} = 0,0058$

Now $+ \frac{1,5385}{0,0058}$ and that found by Hahn is 1,545.
 $= 1,5443$

THIS it is true would be the sp. grav. at 60° , and after 3 days rest (the time I allowed for the penetration of the mixtures mentioned in my tables,) and it does not appear what the temperature of Hahn's mixture was when he took its sp. grav. if it was 44° (the temperature of his oil of vitriol) it is possible that the cold without exact penetration might produce an effect equivalent to that which time would produce by penetration.

2d Experiment.

IN this Hahn added 400 grs. of water to the 1200 grs. of the foregoing mixture, and consequently the new mixture weighed 1600 grs. and contained the same quantity of real acid as the foregoing, that is 628,56 grs. he found its sp. grav. when cold to be 1,38,40.

Application.

Application.

SINCE 1600 grs. of the mixture contained 628,56 real acid, 100 grs. of it should contain 39,28 ; now this quantity of real acid is exactly in the table, and corresponds with the sp. grav. 1,3768. Then the difference between Hahn's result and that of my determinations is $\frac{72}{10000}$.

3d Experiment.

TO the 1600 grs. of the last mixture Hahn added 800 of water, and when the whole was cooled down to the temperature of the air he found the sp. grav. of the mixture 1,2439. Ibid. p. 50.

Application.

THIS mixture weighed 2400 grs. and contained the same quantity of real acid as the last, namely, 628,56 grs. consequently 100 grs. of it contained 26,19; this quantity of real acid is extratabular ; the nearest tabular quantity of real acid is 25,89, which corresponds with the sp. grav. 1,2415; though this seems sufficiently near to Hahn's result, yet I have found it more exactly by the 2d problem. Here $D = 0,0095$ and $D' = 0,89$ and $d' = 0,3$, then by the formula $d = \frac{D d'}{D'}$ we have $\frac{0,0095 \times 0,3}{0,89} = 0,0032$, and the lower sp. grav. $1,2415 + 0,0032 = 1,2448$, which differs from Hahn's result by only $\frac{9}{10000}$.

D

THE

THE 3 first experiments of Hahn not perfectly agreeing with each other, and not having been made with equal accuracy, I omit.

Morveau's Experiment on the Quantity of Real Acid in Vitriolic Acid, whose Sp. Grav. was 1,841. 1 Encyclop. 592.

He took 58 grs. vitriolic acid, whose sp. grav. at $80,5^{\circ}$ Reaum. ($= 51^{\circ}$ Fahr.) was 1,841, and poured into it a solution of acetited barytes until a precipitate ceased to appear. The precipitate washed and dried (by ignition as it would seem by what he adds in the 2d column of the above page) weighed 110,3 grs.

Application.

VITRIOLIC acid, whose sp. grav. at 51° of Fahr. is 1,841, would have its sp. grav. lowered to 1,838 at 60° of Fahr. the degree for which my tables were formed, as I have shewn in my remarks on the alteration by temperature.

Now the sp. grav. 1,838 is intermediate between the tabular densities 1,8306 and 1,8424, but nearer to this; then by the first problem its acid contents will be found to be 78,24 per cent. then if 100 grs. of vitriolic acid of this sp. grav. contain 78,24 per cent. real acid, 58 should contain 45,37 of real acid. But 110,3 grs. of ignited barytes contain 36,76 real acid, allowing 100 grs. of such barytes to contain 33,33 per cent. the difference then between

tween Mr. Morveau's result and that of my calculation is 8.61 grs. ; the reason, however, is obvious ; Morveau employed acetited barytes, this acid rendered part of the acid sulphureous, as is well known ; the sulphureous acid does not decompose acetited barytes per Bergman's table, his other experiments on the sulphureous acid cannot therefore apply.

OF THE TABLE OF NITROUS ACID.

THOUGH this acid was not exactly oxyginated and colourless, yet it was far from being fully de-oxyginated, but in that pale red state in which it commonly appears ; what changes the variety of oxyginations may produce I have not experienced ; the results are not quite so accurate as most of those in the table of vitriolic acid, partly from the eruption of vapour during the weighing, and partly from the disorder the fumes cause at long run in the scales ; but the error in the quantity of real acid in 100 parts of the acid liquor, no where, as far as I have had occasion to examine, amounts to 1 per cent. or at least does not exceed that amount ; the lower part of the table I found most faulty, and have rectified the errors to a great degree.

Experiment 1st.

To 400 grs. of nitrous acid, whose sp. grav. at 63° was 1.4995, Hahn added 200 of water, and when the whole was cooled down to 64° he found the sp. grav. to be 1.3157.

Application.

The sp. grav. 1,4995 at 63° would be (by the table of variation already seen) $1,4995 + 00101 \times 3 = 1,5025$, which scarcely differs from 1,5070, a tabular number, which denotes the acid contents 68,39 — and if 100 grs. of this acid liquor contain 68,39 real acid, 400 grs. contain $68,39 \times 4 = 273,56$, and when 200 grs. of water were added, then 600 grs. contained 273,56, and consequently 100 grs. of the mixture contained 45,59, which indicates the tabular sp. grav. 1,3621, which at the temperature of 64° would be 1,3581.

THIS density differs much from that found by Hahn, being $\frac{42}{1000}$, but that the error proceeds from his not having allowed sufficient time for the penetration of the water and acid, and from the loss of acid by the heat excited will be seen in the examination of the 2d experiment.

Experiment 2d.

To the 600 grs. of the mixture of the last experiment, whose sp. grav. was by him 1,3157, and at 60° would be 1,317, he added 200 grs. of water, and found the sp. grav. of this last mixture at 64°, 1,2561, which at 60° would be 1,2578, the heat excited amounted to 80°.

Application.

Application.

THE sp. grav. 1,317 differs insensibly from 1,316, which indicates the acidity 38,97 per cent. and if 100 grains contain 38,97 :: 600 should contain 233,82 (whereas we have already seen that 600 contains 273,56) and when 200 grains more of water were added, then 800 should contain 233,82, and consequently 100 should contain 29,22 real acid, which indicates very nearly the sp. grav. of this 2d mixture to be 1,237, which differs from Hahn's result

by $\frac{1,257}{0,020}$ by $\frac{20}{1000}$, a difference which, though considerable, is by the half smaller than that of the 1st experiment, as by the interval of time between the 1st and 2d experiment the penetration of the 200 grains of water first added had increased.

THIS calculation is grounded on Hahn's results, which are erroneous from want of rest and the escape of vapours. We shall now see what the sp. grav. of this last mixture should be, if both this and the former experiment were more accurately conducted, and the water so gradually added that little or no heat would be generated, on which principle my former calculation proceeded. This experiment may be considered as a mixture of 600 grains of an acid liquor, whose sp. grav. should, by my table, be 1,3621, and whose acid contents are 273,54 grains with 200 grains of water, and then

800

800 grains (the quantity of this 2d mixture) must contain 273,54 grains of real acid, and consequently 100 grains of this new mixture contains 34,19 grains real acid, which indicates very near the sp. grav. 1,2779, which differs from Hahn's result by $\frac{2}{1000}$, being so much higher.

BUT this same experiment may also be considered as a mixture of 400 grains of the strong acid 1,5025 with 400 grains of water, then as the 400 grains acid liquor contains 273,56 grains real acid as already said, 800 grains of the mixture should contain the same quantity of real acid, and the same sp. grav. would be found to result as above.

Experiment 3d.

IN this experiment he added 2 parts water (suppose 200 grains) to 1 part of the sp. of nitre 1,5025, much heat and copious red vapours were produced, infomuch that a few grains of the weight of the whole were lost (about 3 per cent.) and the sp. grav. was 1,1723, the temperature is not mentioned, but it seems probable it was 64°, the temperature at which, he says, the mixture was made, then at 60° it would be 1,1740.

Application.

HERE the 300 grains of mixed acid liquor contained 68,39 real acid, then 100 grains of it would contain 22,79, which is in the table, and indicates the sp. grav. 1,1845, which exceeds Hahn's result

result by $\frac{1.0}{1.000}$, a difference which evidently arises partly from the escape of the red vapours and partly from want of sufficient time for penetration; it should however be remarked, that in large vessels there may sometimes be an increase of weight from the absorption of oxygen by the nitrous air expelled by the generated heat.

Experiment 4th.

MR. RICHTER (Stoichymetrie, 3 theile, p. 9.) mixed spirit of nitre, whose sp. grav. was 1,5304 with water, in the proportion of 100 parts of the acid with 342 of water, and found the sp. grav. of the mixture 1,123; the temperature is not mentioned.

Application.

100 grains nitrous acid 1,530 contains by my table about 70 grains real acid, and when mixed with 342 of water, 442 grains will then contain 70 real acid, and consequently 100 grains of the mixture will contain 15,83 of real acid, this quantity lies between the tabular acidities 16,17, and 15,44, and by the 2d problem it will be found to correspond with the sp. grav. 1,120.

OF THE MARINE ACID.

THE mixtures of this acid and water are attended with little or no heat, and the sp. gravities are such as may be found by calculation. See 33 Roz. 242. Mr. Berthollet, among his experiments on oxygenated muriatic acid, Mem. Par. 1785, relates that having precipitated a solution of nitrated silver with 500 grains of common muriatic acid, whose sp. grav. was 1,141, he obtained 547 grains of muriated silver, consequently 100 grains of this acid would have afforded 109,4 of muriated silver. Now, as we shall hereafter see, 100 grains of muriated silver contain 16,54 of real marine acid, therefore 109,4 grains of muriated silver should contain 18,02; and by my table 100 grains of the muriatic acid 1,1414 contains 18,57 of real acid.

CHAP.

C H A P. II.

ILLUSTRATION OF THE PROPORTION OF INGREDIENTS
IN VITRIOLIC NEUTRAL SALTS.

BEFORE I treat of these salts it will be proper to notice the state of each of their bases.

OF VEGETABLE ALKALI OR TARTARIN.

THIS alkali may be obtained in three states, the fully aerated and crystallized, the imperfectly aerated or common mild tartarin, and the caustic, which may also by particular processes be crystallized.

THE fully aerated and crystallized contains, by Mr. Pelletier, 41 per cent. of alkali, 43 fixed air, and 16 water, 15 An. Chym. note, however, that even the crystallized is not always fully aerated, 1. Bergman, 16, 17.

COMMON dry salt of tartar contains about 60 per cent. of alkali, 28 or 30 of fixed air, with a few grains of Silex, vitriolated tartarin and argill; common pot-ash generally contains also some grains of vitriolated and muriated tartarin.

Section 1st.

VITRIOLATED TARTARIN.

By my determinations, 86 grains purified and dry tartarin* were saturated by 130 grains of vitriolic acid, whose sp. grav. at 60° was 1,565.

Now this sp. grav. indicates by the table 54,46 real acid; consequently 130 grains of it contained 70,79 real acid, and 86 tartarin + 70,79 real acid = 156,79 vitriolated tartarin.

HENCE 100 parts tartarin take up 82,48 of real vitriolic acid. And 100 parts real vitriolic acid take up 121,48 of tartarin. And 100 grains tartar vitriolate contain 54,8 tartarin, and 45,2 of real vitriolic acid; or in round numbers 55 tartarin, and 45 real acid; or in the proportion of 11 to 9.

Experiment of Dr. Black.

SINCE the publication of the above mentioned determinations, the highly delicate and accurate experiments of Dr. Black, undertaken with the view of ascertaining the contents of the Geyser waters have appeared, with one of which I have compared the foregoing

* By tartarin the mere caustic state is indicated; when it contains fixed air I call it mild; or fully aerated, if it be saturated therewith.

foregoing determinations, and had the pleasure of finding an almost perfect coincidence. See 3 Edinb. Transf. p. 101, 102. Dr. Black to vitriolic acid whose sp. grav. at 60° was 1,798, added 100 times its weight of water, and found that 112 grs. of this dilute acid saturated exactly 1 gr. of tartarin.

Application.

To exclude fractions I shall multiply Dr. Black's quantities by 100; then if 200 grains of vitriolic acid 1,798 were diluted with 20000 grains of water, his dilute acid would consist of 20200 grains, 11200 of such dilute acid would saturate 100 grains of tartarin. Now vitriolic acid 1,798 differs insensibly from 1,7959 which by my table contains 75 grains per cent. real acid. Therefore 11200 grains of such acid so diluted would contain 83,16 real acid, which differs from my determinations only by $\frac{68}{1000}$ of a grain. $83,16 - 82,48 = 0,68$.

HENCE we may find the sp. gravity and quantity of real acid in the sp. of vitriol employed by Wenzel, which it will be useful to know as he made several interesting experiments; and thus also the accuracy of the table of vitriolic acid will be still farther confirmed.

FOR this investigation he has furnished us with two *data*; 1st, he tells us that his sp. of vitriol was formed of two parts of

E 2

highly

highly concentrated vitriolic acid and three parts water, and 2dly, that 240 grains of this sp. contained 75.75 of such acid as is found in ignited tartar vitriolate which is what I call real acid.

WHENCE I deduce that $\frac{2}{5}$ of his sp. of vitriol consisted of the highly concentrated acid, and $\frac{3}{5}$ of water. Now $240 \times \frac{2}{5} = 96$, therefore 96 grains of the concentrated acid contained 75.75 of real acid, then 100 grs. of it would contain 78.9, which quantity belongs to a sp. grav. intermediate between the tabular densities 1,8542 and 1,8424, and by the second problem will be found to be 1,8467, therefore when one part of it is mixed with $1\frac{1}{2}$ of water, or for instance, when 100 grains of it are mixed with 150 of water, (which is the same as mixing two parts with three) the compound amounting to 250 grains contain 78.9 real acid, and 100 grains of this dilute acid contain 31.56 of real acid, a quantity which is extratabular, but belongs to a sp. grav. which by the second problem will be found to be 1,2987.

THEREFORE the sp. grav. of Wenzel's oil of vitriol is 1,8467 containing 78.9 real acid per cent. and the sp. grav. of his spirit of vitriol was 1,2987, containing 31.56 per cent real acid.—261,976 (262 grs.) of his spirit of vitriol would saturate 100 grs. of tartarin.

1000 grains of Dr. Black's dilute vitriolic acid contained 7,425 real acid. As I found it has lately been denied that vitriolated tartarin

tartarin contained 45 per cent. real vitriolic acid, I dissolved 100 grains of it in six ounces of water, and precipitated the acid by muriated barytes, the resulting baroselenite weighed after ignition 135,25, which proves as we shall presently see that the vitriolated tartarin contained 45,078 grains of real acid.

Section 3d.

OF SODA AND VITRIOLATED SODA, OR GLAUBER.

As soda may be had either chrySTALLIZED, effloresced or deficcated, it will be necessary to examine the proportion of real alkali in each, in order to find the proportion in neutralized compounds.

1st. In its crystallized state even when recently formed, I found the proportion of its ingredients somewhat variable, but in the greater number of experiments the crystals being dried in filtering paper in a temperature not above 66° , and the air not much disposed to give out moisture. I found 100 parts of the crystals to contain 64 of water, 21,58 of real soda, and 14,42 of fixed air. 36 Grains therefore of aerated but deficcated soda are equal to 100 grains of the crystallized, that is, contain the same quantity of alkali.

2dly

2dly, IN its simply effloresced state the quantities are variable according to the more or less perfect efflorescence, the state and temperature of the air.

3dly, 100 parts *soda fully aerated but thoroughly desiccated* in a heat somewhat below ignition contains 59,86 alkali or mere soda, and 40,05 of fixed air per cent. or nearly 60 of alkali, and 40 of fixed air. In the experiments in my former paper the soda was heated to ignition, and thus part of the fixed air was probably expelled, for I found only 36 per cent. of fixed air.

OF GLAUBER.*

By my determinations, 100 *parts of soda* (that is, mere soda, dry and free from fixed air) are saturated by 127,68 of real vitriolic acid. And 100 parts of real vitriolic acid are saturated by 78,32 of soda. Hence if Glauber contained *no water*, 100 parts of it would contain 43,92 of soda and 56,08 of real vitriolic acid, or nearly 44 *soda* and 56 *real acid*; and this is the state of glauber thoroughly desiccated.

BUT *crystallized Glauber* contains a large proportion of water, for 100 parts of it *lose* 58 by a heat somewhat below ignition, therefore 42 parts only remain which contain alkali and acid in the proportion above mentioned of 44 to 56, that is, 18,48 of alkali and 23,52 of acid.

* This salt being long known by the name of Glauber's salt, I shall simply call Glauber, this being shorter, and serving as a memorial of the antient denomination. It claims by the same (but a much elder) title, as *Scheelium* and *Witherite*.

HENCE 1st. 42 grains of desiccated Glauber are equivalent to 100 of the crystallized.

HENCE 2^{dly}, 100 grains desiccated Glauber should give, or are equivalent to, 238 of the crystallized, that is, they contain the same quantity of alkali and acid as 238 of the crystallized.

HENCE 3^{dly}, 100 grains of soda saturated with vitriolic acid should give 541 + of crystallized Glauber, or 227 of desiccated Glauber, and 100 parts crystallized soda should give 116,77 of crystallized Glauber; or 49 desiccated Glauber, and 100 grains real vitriolic acid should give when saturated with soda (whether crystallized or not) 425 + of crystallized Glauber or 178,5 of desiccated.

BUT these quantities of desiccated or crystallized salt are never *exactly* obtained, on account of the loss by evaporation, and of what remains in the mother liquor.

Application.

ON THE PROPORTIONS IN AERATED SODA.

Experiment 1st. Dr. Black's. 3 Edinb. Transf. 106.

HIS quantities being fractionary to render the calculation clearer, I multiply all into 1000.

He

HE found 2380 grains crystallized soda to contain 514 of mere caustic alkali, then 100 should contain 21,17 of alkali, which differs from my result by less than $\frac{1}{2}$ a grain. Hence 21,17 grains of mere soda are equivalent to 100 grains of the crystallized.

AGAIN, he found that 2380 grains of crystallized soda lose by thorough desiccation 1523 grains, and consequently are reduced to 857 grains, therefore 100 grains of the crystallized are reduced to, and are equivalent, as to real alkaline contents, to 36 grains, losing therefore 64 grains of mere water.

AND, lastly, he found that 857 grains of desiccated soda contain 514 of mere caustic soda, and consequently 100 grains of the desiccated contain nearly 60 of mere soda, and consequently 40 of fixed air. All these results agree almost exactly with mine.

Experiment 2d. 1 Klaproth, 333.

IN his experiment 1000 grains of dry crystallized soda lost when thoroughly desiccated in a sand-heat, 637 grains of water, consequently 100 should lose 63,7, which scarcely differs from Dr. Black's result, then the dry residuum amounts to 36,3 grains.

OF THE PROPORTIONS IN GLAUBER.

1st Experiment. Dr. Black's, 3 Ed. Transf. 106.

514 grains of mere soda were saturated by 88180 of the dilute vitriolic acid before mentioned in treating of vitriolated tartarin.

Application.

SINCE 514 grains of mere caustic soda require 88180 of the dilute acid, 100 grains of soda would require 17155, and since 1000 grains of this acid contains 7,425 of real acid, 17155 contains 127,37 grains. A result which differs from mine by less than $\frac{1}{3}$ of a grain.

2d Experiment. 1 Klapr. 333.

100 grains of the thoroughly desiccated soda above mentioned require for their saturation 382 of a dilute vitriolic acid, formed of a mixture of 1 part vitriolic acid, whose sp. grav. was 1,850 and 3 parts water, and the resulting neutral salt weighed 132,5 grains.

He also found that 1000 parts newly crystallized Glauber, dried betwixt filtering paper, afforded by thorough desiccation in a sand-heat only 420 grains, and therefore lost 580.

F

Application.

Application.

THE sp. grav. 1,850 is extratabular, lying between the tabular sp. gravities 1,8542 and 1,8424, but nearer to the former; its acid contents are 79,14 per cent. then if 200 grains of this acid be diluted with 3 times that weight of water, we shall have 800 grains of a dilute acid, which will contain $79,14 \times 2 = 158,28$ grains of real acid; then 382 grains (the quantity employed by Klaproth) contain 75,57 of real acid, now 100 grains of deficcated soda contain, as we have seen, 60 of mere caustic soda, and since 100 grains of mere soda require 127,68 for their saturation, 60 grains of such soda should require 76,60; the difference then between Klaproth's result and my determination is only 1,03 grains.

LASTLY, it may naturally be expected, that the resulting neutral salt should amount to the joint weight of the real acid and mere alkali, and consequently should in this case weigh $75,57 + 60 = 135,57$ grains, which differs from Klaproth's result only by 3,07 grains, a loss which may well be imputed to that which the salt suffers by evaporation.

THESE concordant experiments fully prove the accuracy of the table of vitriolic acid to a large extent, and of the proportion of ingredients I have assigned to soda, vitriolate tartarin and Glauber; for as Klaproth's experiments were made with an acid whose sp. grav.

grav. was 1,850, Dr. Black's with an acid whose sp. grav. was 1,798, and mine with an acid whose sp. grav. was 1,565, we may be assured that to that extent (which includes 25 determinations) no material error exists.

WE must not however imagine, that all mineral alkali contains the same proportion of ingredients as soda; for the natural mineral alkali found in Africa, and called *trona*, contains a somewhat larger proportion of fixed air and a much smaller of water. 195,6 grains of trona, which Dr. Black had the goodness to send me, were saturated by 260,5 of vitriolic acid 1,383, and gave out 66,5 grains of fixed air, therefore 100 grains of trona would require 133,18 of this acid for their saturation, and would lose 34 grains of fixed air.

Now this acid differs insensibly from the tabular, whose sp. grav. is 1,387, which contains 40,18 grains per cent. real acid, and therefore 133,18 grains of it contains 53,5 of real acid. But we have shewn that 100 parts real vitriolic acid saturate 78,32 of mere mineral alkali, therefore 53,5 grains of this acid saturate 41,9; this therefore is the quantity contained in 100 grains of trona, then $41,9 + 34$ of fixed air = 75,9 and 1,8 grains of reddish earth, consequently the remainder, that is 22,3 grains, were water.

HERE we see the alkali takes up more fixed air than usual, for since usually 60 of the alkali take up 40 of fixed air, 41,9 of the

pure trona should take up but 27,91, or nearly 28, whereas here it takes up 34, which is owing to its retaining but a small portion of water during its crystallization.

HENCE also we find the proportions in Mr. Keir's effloresced but dry soda, for he tells us, that 100 grains of such soda were saturated by 90 grains of vitriolic acid, whose sp. grav. was 1,800; now this acid differs insensibly from the tabular, whose sp. grav. is 1,807, which contains 75,89 real acid, consequently 90 grains of this acid contains 71,9 real acid; and since 127,68 real vitriolic acid take up 100 of mere soda, 71,9 should take up 56,31; and as 60 of mere soda take up 40 of fixed air, 56,31 should take up 37,53, the sum of both is 93,84, then the remainder of the 100, that is 6,16 parts, are water, which remained as it was not dried by ignition.

MR. KEIR also found that 100 parts of an impure Indian fossil alkali contained as much real alkali as 58,8 grains of the above effloresced and dry soda, and were saturated by 53 grains of the vitriolic acid 1,800. Now, from the proportions above stated, it will be seen that 58,8 of his soda contain 33,11 of mere alkali, and that 53 grains of the acid contained 40,22 of real acid, and that these should saturate, and thereby indicate 31,5 of mere alkali, which differs from his result by 1,61 grains*.

LASTLY, the proportions assigned to crystallized tartarin and to crystallized soda, and also the proportions of mere tartarin and mere

* Transf. of the Society of Arts and Manufactures. Vol. 6, p. 130, &c.

mere soda taken up by a given weight of real vitriolic acid, are confirmed by an experiment of Mr. Fourcroy's, 2 Ann. Chy. 289. for he found that the *same quantity* of vitriolic acid which saturated 193 grains of the crystallized soda also saturated 188 of crystallized tartarin. Now I have assigned 21,58 per cent. of mere alkali to crystallized soda, therefore 193 grains of it contain 41,6, and as the crystallized tartarin contains 41 per cent. of alkali, 188 grains of it contain 77. I have also shewn that 100 grains real vitriolic acid take up 78,32 of mere soda, and 121,48 of mere tartarin, then the harmony of these proportions with Fourcroy's experiments will thus appear: as 78,32. 121,48 :: 41,76,36; the difference between us is only 0,64 of a grain.

Section 3d.

BAROLITE AND BAROSELENITE.

100 parts barytic earth precipitated from its solution in acids by a mild alkali, whether fixed or volatile, and heated to gentle ignition, contains 78 or 79 parts of earth, 21 or 22 of fixed air, about 1,5 are stronthian earth, a quantity which in this case deserves little attention. See 1 Klapr. 271. 2 Klapr. 82 and 86. 2 Chy. Ann. 1793, 196. 1 Chy. Ann. 1795, 111. Hence 100 grains barytic lime take up 28,2 of fixed air, and 100 grains of fixed air would precipitate 354,5 of barytic earth, and probably more, as the earth may not be saturated.

BAROSELENITE

BAROSELENITE OR VITRIOLATED BARYTES.

BARYTIC Solutions being the most delicate test of vitriolic acid as yet known, the determination of the proportion of real vitriolic acid taken up in the artificial compound of both is of the greatest importance, and its agreement with the foregoing determinations will tend to their mutual establishment.

I HAVE already mentioned that by real vitriolic acid I mean acid of such strength or concentration as exists in well-dried and neutralized vitriolated tartarin. If therefore I can shew in what proportion the acid contained in a given weight of this salt enters into the composition of a given weight of thoroughly dried baroselenite, the proportion of real acid in this last will of course be demonstrated. Now this may very nearly be ascertained by the experiment of Dr. Withering, Phil. Trans. 1784, p. 304. But first I must premise that by the experiments of the most accurate analysts, 100 parts baroselenite when sufficiently dried contain very nearly 33 of vitriolic acid.

THE results obtained by Dr. Withering were as follow :

1st. 480 grains of baroselenite being fused with 960 of salt of tartar, 428 grains of the baroselenite were decomposed, and 52 remained undecomposed.

2dly.

2dly. THE decomposed part nevertheless weighed after decomposition only 360 grains.

3dly. 300 grains of vitriolated tartarin were also obtained.

IN this experiment we are only to attend to the 428 grs. which were decomposed, as the 52 that escaped decomposition were no way altered.

IN the first place it is plain that the 428 grains that were decomposed contained at least as much vitriolic acid as they imparted to the alkali in forming 300 grains of vitriolated tartarin: Now 300 grains of vitriolated tartarin contain $45 \times 3 = 135$ of real vitriolic acid, therefore 428 grains of baroselenite contain at least 135 of real vitriolic acid, that is, 31,5 per cent. a quantity that already approaches pretty nearly to the direct results of most analysts. But in the next place it is equally evident, that the quantity of acid was greater than here stated, and the quantity of mere barytic earth much below 360 grains, the quantity expressed in the 2d result; for if this quantity were just, the sum of its weight and of that of the acid would surpass the weight of the decomposed part. As instead of 428 the sum would amount to $360 + 135 = 495$, which is impossible. The truth then is, that those 360 grains of residuary earth comprehend the weight not only of the mere earth, but also of the fixed air, which it had taken from the alkali in exchange for the acid it had imparted

imparted to it; consequently to find the true quantity of acid we must find out how much of the residuary 360 grains were mere earth, for by deducting this quantity from 428, the remainder will express the quantity of acid in the 428 grains.

THEN let the quantity of earth in the 360 grains = x , and the quantity of fixed air = y , then $x + y = 360$. and $x : y :: 78 : 21$ * nearly; and therefore $21 x = 78 y$, and $x = \frac{78 y}{21}$, then $y + \frac{78 y}{21} = 360 \times 21 = 7560$, and $21 y + 78 y = 7560$ or $99 y = 7560$, and $y = \frac{7560}{99} = 76,36$ grains of fixed air; and deducting this from 360, we have the quantity of mere earth = $360 - 76,36 = 283,64$; and deducting this quantity from 428, we have the quantity of vitriolic acid = 144,36 grains; and lastly, if 428 baroselenite contain 144,36 of vitriolic acid, 100 grains baroselenite should contain 33,64.

THIS last quantity of acid somewhat exceeds the usual centenary proportion obtained by chymists, yet I believe the saturating proportion of acid to be still higher, for the following reasons:— There are three ways of adding to each other an acid and earth or metal, the one by dropping the acid to be combined into the solution of the earth in an acid to which the earth hath a weaker affinity, and the other by inserting the earth immediately into the

* I say 21 rather than 22, as Dr. Withering himself states it at 20,8.

the acid with which it is to be combined, or by dropping its solution in a weaker acid into the acid with which it is intended to be combined. In the 1st mode of combination the saturation is scarce ever complete, because the new compound in many cases precipitates before it is fully saturated, and even though there should be an excess of the acid to be combined in the liquor, yet the inferior part of the precipitate seldom receives it, being sheltered by the superior, and because its affinity to its last complement of acid is much weaker than that to its *mean* proportion of acid.

BUT in the 2d or 3d mode of addition, the earth being surrounded by the acid with which it is to be combined, and thus exposing a greater surface, takes up more of it and even frequently an excess, as I have often experienced.

This explains the difference which may be observed in the experiments I shall now state:

1st. DR. WITHERING having made a solution of 100 parts native aerated barytes in muriatic acid, dropped vitriolic acid into it until a precipitation ceased to appear; this artificial baroselenite weighed 117 grs. Phil. Transf. *ibid.* 405. Now this native barytes contained but 78, 6 of pure barytic earth, as he had proved in a former experiment; therefore 78,6 of barytic earth took up as much real vitriolic acid as raised its weight to 117 grs. namely 38,4 grs.; and if 117 grs. baroselenite contain 38,4 grs. of vitriolic acid, 100 parts baroselenite must contain 32,8.

So also Klaproth tells us, that a baroselenite which he had formed by dropping vitriolic acid into a muriated solution of aerated barytes contained barytic earth and acid nearly in the proportion of 2 to 1, consequently 100 parts of it contained 66,66 of earth and 33,33 of real vitriolic acid. 2 Klapr. 72.* And p. 97 he tells us, he found the same proportion in another experiment, as 126 baroselenite contained 42 of real acid.

ON the other hand, Fourcroy having dissolved 100 grs. native aerated barytes with the assistance of heat in very dilute vitriolic acid, found it to afford 138 grs. of baroselenite, (instead of 117 which Dr. Withering had found by the 1st method) and that the barytic earth had taken up 48 parts vitriolic acid. Now if 138 parts baroselenite contain 48 of acid, 100 must contain 34,78. 4 Ann. Chym. 65.

KLAPROTH found that 85,5 grs. vitriolic acid whose sp. grav. was 1,850, entered into the composition of 194 grs. baroselenite, and by his own rule $\frac{1}{3}$ of these 194 grs. were real acid = 64,66; therefore 100 grs. of baroselenite should contain 33,33 grs. real acid. 1 Klapr. 153. By my table, as already said, 100 grs. vitriolic acid, whose sp. grav. is 1,850, contains 79,14 grs. real acid, therefore 85,5 grs. of this acid should contain 67,7 real acid, and if

194

* The baroselenite in all these cases was ignited, and he found that 185 grs. merely dried weighed after ignition 180, consequently 100 parts of the merely dry lose about 2,7 or 2,8 by ignition.

194 grs. barofelenite contain 67,7, 100 grs. of the barofelenite should contain 34,92, which differs from Klaproth's results by 1,59 grs.

AGAIN, Dr. Black, in the analysis of Geyser Waters, p. 117, tells us that 170 grs. barofelenite contain as much acid as 100 of fully deficcated Glauber. Now I have already shewn by my own experiments that 100 grs. of deficcated Glauber contain 56,08 of real vitriolic acid, therefore 170 of barofelenite contain the same quantity, and if so, 100 grs. barofelenite must contain 32,98, very nearly 33, which we see scarcely differs from Klaproth's proportion, the quantity of real acid being computed from my table.

LASTLY, Klaproth found that 100 grs. of deficcated Glauber decomposed by acetited barytes gave 168 grs. of barofelenite. 1 Klapr. 333. Then 168 grs. barofelenite contain 56,08 of real vitriolic acid, and 100 should contain 33,38 of this acid. The consonance of these results with my table may hereby be easily discerned. In general then the quantity of real acid in any quantity of ignited barofelenite may be discovered by dividing it by 3, it being $\frac{1}{3}$ of the whole weight.

HENCE 100 parts barytic earth take up 50 of real vitriolic acid, and would give 150 of barofelenite. And 100 grs. real vitriolic acid take up 200 of barytic earth, and afford 300 of barofelenite.

Section 4th.

AERATED STRONTHIAN.

100 parts native aerated stronthian, or of the artificial sufficiently dried, contain 31 of fixed air and 69 of earth.

HENCE the quantity of air in any given quantity is found by multiplying this quantity into 0,31, and the quantity of earth by multiplying it into 0,69; then 100 parts of this earth are saturated by 45 of fixed air, and 100 parts of fixed air by 222,5 of this earth.

ACCORDING to Dr. Hope, 100 grs. of crystallized stronthian lime contain 32 of earth and 68 of water.

LOWITZ found 100 grs. of the artificially aerated stronthian to contain, when dried in heat, 32,5 per cent. of fixed air. 1 Chy. Ann. 1796. 128.

PER Pellitier, 100 grs. native aerated stronthian calcined with 10 grs. charcoal lost only 28 grs. 21 Ann. Chy. 124.

VITRIOLATED STRONTHIAN.

100 Parts vitriolated stronthian contain 42 of real vitriolic acid, for this is the quantity which muriated barytes separated from the tartarin

tartarin which decomposed 100 parts of vitriolated stronthian, consequently the earthy part amounts to 58 grs. 2 Klap. 96, 97. Then 100 of this earth take up 72,41 of real vitriolic acid; and 100 grs. real vitriolic acid would take up 138 of stronthian earth.

Section 5th.

AERATED LIME AND SELENITE.

IN artificial aerated lime formed by precipitation, by soda or even by common tartarin, if added to excess, the proportion of lime to fixed air is constant, being as 55 of the lime to 45 of the air, that is, as 11 to 9, so that the quantity of air being given that of the lime in the compound may be known; and if the compound be free from any other ingredient, and heated to redness to free it from water, then its weight being given the quantity of lime it contains is found by multiplying it into 0,55, and the quantity of air by multiplying it into 0,45; but whether dry or not, the weight of the air being found, the weight of lime is found by the 1st analogy.

MR. BERGMAN repeatedly asserts, that 100 grs. of calcareous spar contain 55 of mere lime, 11 of water, and only 34 of fixed air. It always gives me concern to find my results different from those of this great man, but on this occasion I am happily able to detect the causes of this difference.

ist. He tells us that by flow solution of 100 grs. of the spar in acids he found the loss of weight to amount to 34 grs. only, though by applying a strong heat he found it to amount to 45. Hence he concludes that in solution the fixed air singly was expelled, but that both fixed air and water were expelled by heat. Now to obtain a flow solution in acid he must have used a very dilute acid, and have employed a very narrow mouthed vessel. In this case much of the fixed air is reabsorbed by the solution, as daily experience shews, and thus must have prevented his perceiving the real quantity of the air expelled from its combination with the earth.

AGAIN Lavoisier computes 100 grs. of chalk to have lost about 34 grs. of air by solution in nitrous acid; but this loss he inferred not from a direct trial, but from the weight of the volume of air found by comparison with that of common air, calculated according to Mr. De Luc's rules. This concurrence must undoubtedly have confirmed Mr. Bergman in this erroneous estimation.

So also in natural lime-stones, the quantity of fixed air being found that of the lime is in the above proportion, except in a few cases where magnesia exists in them or the lime not saturated. Hence 100 grains lime take up 81,81 of fixed air, but 100 grains of it are precipitated by somewhat less. Klaproth estimates the proportion in this at 4 of fixed air to 5 of lime. And 100 grains fixed air saturate 122,24 of lime, but would precipitate 125.

Section

Section 6th.

SELENITE.

THERE are two ways of combining vitriolic acid with lime and some other substances; one by *direct solution* or addition of the basis unto perfect saturation, so as no longer to discolour the usual tests, the other by precipitation from another menstruum; in this last method the basis takes up an excess of acid, which as it is washed off in other pursuits occasions no mistake, though it does in this.—The 1st experiment in my last paper I followed the 1st method, in it I found that 439 grains of a mixture of 225 grains of vitriolic acid whose sp. grav. at 60° was 1,5654, with 225 of water, saturated 152 grains of marble which contained (at the rate of 55 per cent.) 83,6 of lime. By the table it appears, that the vitriolic acid before dilution contained 54,46 real acid, then 439 of the dilute acid contained 119,5 of real acid, consequently 83,6 of lime took up 119,5 of real vitriolic acid, therefore if the compound of both were free from water, we should have its weight equal $83,6 + 119,54 = 203,14$ nearly, and 100 parts of it would contain 41,15 lime and 58,84 of real acid.—But unless the compound be exposed to a high heat this weight cannot be expected; the resulting selenite will always retain a proportion of water, varying with the degree of heat to which it was exposed, and it is this that occasions the variety of determinations of the proportion

portion of ingredients in felenite, when, as in this experiment, its ingredients are directly combined; yet the proportion taken from the quantity of precipitate is more fallacious, as will presently be shewn.

In this direct experiment the quantity of felenite obtained after deficcation in a heat not exceeding 170° , amounted to 237.25 grains, of these 203.14 were lime and real acid; the remainder then ≈ 34.11 were water; then by the rule of proportion 100 grains of this felenite should contain 14.38 of water, consequently 85.62 were lime and acid. And if 100 parts of such compound contain 41.15 of lime, as already seen, 85.62 should contain 35.23, and deducting this from 85.62, we have 50.39 for the acid part, consequently the centenary proportion of ingredients in felenite dried at about 165° is as follows:

Real vitriolic acid	-	50.39
Lime	- - -	55.23
Water	- - -	14.38
		<hr/>
		100.00

If the felenite were dried by mere exposure to the air, the quantity of water in 100 parts of the felenite would be greater, and that of the lime and acid smaller, and if it were ignited the proportion of these last would be greater, and that of the water smaller,

smaller, as is evident; but by exposing any quantity of it to a strong red heat the water will, for the most part at least, be expelled, and the proportion of the other ingredients may be determined very nearly by the above analogy, if the felenite be faturate and free from foreign ingredients.

THE experiments I made in precipitating lime from the nitrous and marine acids by the vitriolic, and also by vitriolated tartarin, I found to be fallacious, as much of the felenite remains in solution in these acids, and consequently it is not possible to limit or discover the proper addition of the precipitant. Hence 100 *grains lime* take up 143 nearly of real vitriolic acid, and afford about 284 of felenite thus dried and formed. And 100 grains real vitriolic acid take up nearly 70 of lime, and afford 198 of felenite thus dried and formed.

100 grains lime precipitated by vitriolic acid take about 15,8 per cent. excess of real acid, and vitriolated tartarin does not precipitate the whole of it without repeated evaporations and additions.

Experiment 1st. 1 Klaproth, 195.

ACCORDING to Klaproth 100 grs. of vitriolic acid, whose sp. grav. was 1,850 (neglecting he says insignificant fractions) were saturated by 55 of lime or 100 of aerated lime, and afforded 160 grs. felenite.

H

Application.

Application.

100 grs. of the vitriolic acid 1,850 contain 79,14 grs. per cent. of real acid as already seen; then if there were no water in the compound its weight would be $79,14 + 55 = 134,14$ grs. but he found the weight to be 160, then the difference or $160 - 134$ must be water = 26 grs.

Then the centenary proportion was

{	49,47 real vitriolic acid
	34,37 lime
	16,25 water
	100,00

This proportion we see scarcely differs from mine and therefore his felenite was probably exposed to nearly the same heat.

Experiment 2d. 2 Klaproth, 124.

In this experiment he tells us the felenite was heated to *ignition*, and consequently we may see the difference of proportion produced by that heat. 38 grs. of it contained 14,75 of lime; the quantity of acid is not mentioned.

Application.

Application.

By his own proportion 14,75 lime should take up 21,22 of real acid, for as $55:79,14::14,75:21,22$ nearly, then $1745, + 21,22 = 35,97$, consequently the remainder *v. z.* 2 grs. were water, then the centenary proportion should be

as $38:14,75::100$ to	38,81 lime
$38:21,22::100$ to	55,84 real acid
then the remainder is	5,35 water
	<hr/>
	100,00

Experiment 3d. 1 Bergm. 135.

BERGMAN's felenite is crytallized and contains so much water that it is plain he supposes it dried by mere exposure to the heat of the atmosphere.

according to him 100 grs. contain	46 vitriolic acid
	32 lime
	22 water
	<hr/>
	100

HENCE 1st, we have the proportion of felenite dried in 3 different degrees of heat, that of ignition, that of the atmosphere, and that between 130° and 170° .

H 2

2dly. WE

2dly. We may now explain and do justice to the *first* experiment of Mr. Wenzel on this subject. He dissolved 240 grs. of clean oyster shells in his spirit of nitre, and precipitated the lime contained in them by dilute vitriolic acid, he then evaporated the whole, first to dryness and afterwards by gentle ignition to expel the excess of acid, and lastly exposed the selenitic mass to a more intense heat for one hour, then weighing it in the same vessel found the selenite to weigh 309,75 grs.

Application.

THE 240 grs. of purified oyster shells contained 126,72 grs. of lime, which I prove thus, he tells us p. 101, that 81 grs. of the same oyster shells gave out during solution 35 grs. of fixed air, consequently 100 grs. would give out 43,2; now we have already seen that 45 grains of fixed air denote the presence of 55 of real calcareous earth in 100 parts aerated lime, therefore 43,2 denote 52,8 of lime and therefore 240 parts of these shells contained 126,72.

Now as to the acid, since 100 parts lime take up 143. 126,72 should take up 181,20 and the selenite being so strongly heated should weigh only the sum of both *v. z.*: $181,20 + 126,72 = 307,92$ or 308, grains which wants only 1,75 of the weight found by Wenzel, this increase found by him I impute to some phosphorated lime originally in the shells, the acid of which was not expelled in the above experiment.

WENZEL

WENZEL was set astray by his 2d experiment; for having calcined 240 grains of his shells for 4 hours he concluded they were wholly converted into lime and he found their weight 133,5, but here lay the mistake, he had no proof that 3 or 4 grains did not remain uncalcined, and the presence of phosphorated lime he did not suspect. In a third experiment he came very near the truth for he concluded the quantity of lime to be 125 grains, but the difference between this and 133,5 he attributed to the *causticum*.

Section 7.

OF MAGNESIA AND EPSOM.

THIS earth may be obtained in three states, either *fully aerated and crystallized*, and then from its great solubility in water it may be called a salt; or *imperfectly aerated*, such as *common magnesia*; or *perfectly deaerated* and freed from water by a white heat.

THE proportion of ingredients even in crystallized magnesia are differently stated, probably from having undergone some unperceived efflorescence; according to Fourcroy who seems to have bestowed most attention to this object, 100 parts crystallized magnesia contain

50 fixed air
25 magnesia
25 water

100.

hence

hence they lose 75 per cent. of their weight when strongly heated
2 An. Chy. 297, 298.

BUT according to 1 Bergm. 29 and 373, the chrystallized contains but 30 per cent. of fixed air, with whom Butini agrees, but he afterwards found even common magnesia to contain a larger proportion, see p. 23 and 146 of his treatise; of the other ingredients neither mentions the proportion.

IN *common* magnesia the proportions are, according to Bergman

45	of earth
25	fixed air
30	of water
<hr/>	
100	

AND according to Butini p. 146,

40,62	earth
37,5	fixed air
21,88	water
<hr/>	
100,00	

ACCORDING to Fourcroy 100 parts of common magnesia contain

40	earth
48	fixed air
12	water
<hr/>	
100	

consequently they should lose 60 per cent. in a white heat.

CONSEQUENTLY

CONSEQUENTLY per Bergman 100 grs. common magnesia should lose 55 per cent. in a strong heat, and per Butini it should lose nearly 60, and with this determination two experiments of Klaproth's agree. See 2 Klapp. 9 and 20; yet in another experiment the loss was but $\frac{46}{100}$, 2 Klapp. 174.

HENCE we see the proportions of air and water are variable, but the sum of both generally amounts to 55 per cent. at the least, and and hence I rate the mere earthy part in common magnesia at 45 per cent. when by a strong heat less is found I believe the difference to have been volatilized. The various proportions of fixed air arise from the various proportions of it contained in the different precipitants used in obtaining magnesia.

Note however, the water may gradually be expelled from common magnesia in a heat much below ignition.

EPSOM.

IN my former paper I have stated that 35 grains of common magnesia, containing 15,75 of mere earth, were saturated by 50 grains of vitriolic acid, whose sp. grav. was 1,5654, diluted with a large proportion of water, but containing, as appears by the table, 27.23 real acid, and from this and a comparative experiment, I deduced that 100 parts of crystallized Epsom contained 17 of mere earth,

earth, 29,35 of real vitriolic acid, and 53,65 of water, it was standard acid that I had before mentioned, but its quantity of real acid is as I now state it, as may be seen by calculation.

HENCE 100 parts perfectly desiccated Epsom should contain 36,68 nearly of earth, and 63,32 nearly of real acid.

AND 100 grains mere magnesia take 172,64 real vitriolic acid, and should afford 590 nearly of crystallized Epsom.

AND 100 parts real vitriolic acid should take up 57,92 of magnesia, and afford 340 nearly of crystallized Epsom.

ACCORDING to Bergman 100 grains of magnesia take up 173 of real vitriolic acid.

ACCORDING to Wenzel 100 grains magnesia take up 181,8 real acid, this arises from his rating the mere earthy part of common magnesia at 41,2 per cent. which, as I think, arises from volatilization of part of the magnesia.

Experiment 1st. Fourcroy, 2 An. Chy. 285,282.

HE found that crystallized tartarin taken in the proportion of 80 parts to 100 of crystallized Epsom operate an *almost total* decomposition of the Epsom.

Application.

Application.

As 100 parts crystallized tartarin contain, as already said, 41 of vegetable alkali, 80 parts of it must contain 32,8, but as 100 parts of this alkali take 82,48 of real vitriolic acid, 32,8 should take 27,05, which is nearly the whole of what 100 parts of Epsom contain.

Experiment 2d. Fourcroy, 2 An. Chy. 288.

CRYSTALLIZED foda, applied in the proportion of 108,8 to 100 of crystallized Epsom, perfectly decomposed the Epsom.

Application.

100 parts crystallized foda contain, as already shewn, 21,58 of mere alkali, consequently 108,8 parts contain 23,479. Now 100 parts of this alkali take up 127,68 of real vitriolic acid; therefore 23,479 should take 29,97, which differs from the quantity of acid I have assigned to 100 parts crystallized Epsom only by 0,62 of a grain.

*Section 8th.***ALUM.**

THE combinations of argill with vitriolic acid are so diversified, as Mr. Vauquelin has lately shewn in a series of curious and interesting experiments, that to ascertain the limits of each would require a particular examination which the generality of the present inquiry does not at present permit to enter into.

THE result of my former essay was, that 100 parts alum contain 31,34 of earth dried at 465° ; 17,66 of real vitriolic acid, and 51 of water; but the acid contained in vitriolated tartarin, of which alum may contain 6 or 7 per cent. is not noticed; but being counted the whole amounts to 20 per cent.

THE earth heated to *whiteness* may be reduced to 18, or still fewer parts. Wenzel and others say 11,7, and I believe this to be most exact.

HENCE 100 grains burnt alum, that is alum from which its water was expelled, should contain 35,4 of real acid. But the alums of different countries differ much. See Vauquelin in An. Chy. & Pref. to 1 Laborant. VII.

Section

Section 9th.

VITRIOL OF IRON.

100 parts of this vitriol newly crystallized contain by my determination 28 calx of iron in the state of æthiops, equal nearly 22 of metallic iron, 26 real vitriolic acid, 38 water of crystallization, and 8 water of composition, that is which adheres to the acid. This determination I lately confirmed; for from a solution of 100 grains of this vitriol decomposed by muriated barytes I obtained 77,25 of ignited baroselenite, which at the rate of 33,3 per cent. contained 25,747 of real vitriolic acid.

HENCE 100 parts vitriol of iron calcined to redness contain 41,93 of real acid, and 12,9 of water; but the calx of iron will weigh more than 45, as it attracts oxygen during the calcination.

THE water of composition is for the most part expelled with the acid during distillation. Then 22 grains metallic iron should afford 100 grains of crystallized vitriol; and 100 grains of the best iron would give 454,54 of vitriol.

THE vitriol above examined was of a full *grass green colour*. I have met with another which is of a pale sea green colour, and contains much less acid, for 100 grains of it treated as above afforded only 56,7 of baroselenite, and consequently contained but 18,99 of real acid.

Section 10th.

VITRIOL OF LEAD.

By the experiments of Klaproth, 100 grains vitriol of lead should contain about 71 of metallic lead;* by those of Bergman and Wenzel nearly 70; but as the lead, being precipitated from the nitrous acid, is in a calcined state, we may add 4 of oxygen.

AGAIN, Wolfe found 120 grains vitriol of lead decomposed by tartarin to afford 65 of vitriolated tartarin; therefore 100 grains of this vitriol would afford 54,16 of vitriolated tartarin. Now this quantity of vitriolated tartarin contains 23,37 of real vitriolic acid; therefore just so much is contained in 100 grains of vitriol of lead. Phil. Transf. 1779. and 10 Roz. 368.

HENCE the quantity of ingredients *in 100 parts of this salt* are 75 calx of lead, (= 71 of metallic lead) 23,37 real vitriolic acid, and 1,63 water.

HENCE 100 *grains metallic lead* (with the addition of oxygen) take up 32,91 of real vitriolic acid, and afford 140 of vitriolated lead.

AND 100 *parts real vitriolic acid*, unite to 303,8 of metallic lead, (when calcined) and afford 425,49 of vitriol of lead.

ACCORDING

* See 1 Klapr. p. 169, and 173; and 2 Klapr. p. 219.

ACCORDING to Bergman, 100 grains metallic lead would afford 143 of vitriol of lead.

ACCORDING to Wenzel 143,33.

ACCORDING to Wolfe 137,5. He precipitated the nitrous solution of lead by vitriolated tartarin, and probably did not apply enough, or this salt did not disengage the last portions of the nitrated lead, or some part of the vitriol of lead remained in the nitrous acid. This last supposition is highly probable.

VITRIOL OF COPPER.

100 grains of this salt, perfectly crystallized, lost 28,5 by exposure to a heat of 370° .

By precipitation with muriated barytes they afforded 91 of ignited baroselenite, and hence contain 28,5 of water of crystallization and 30,33 of real vitriolic acid; and consequently about 40 of calx of copper = 32 of metallic copper.

VITRIOL OF ZINC.

100 grains of vitriol of zinc, crystallized in needles, lost in a heat of 375° 39 grains; and 100 grains of the same crystals, being dissolved and treated with muriated barytes, afforded 61,24 of ignited baroselenite, and hence contain 20,414 grains of real vitriolic acid.

CHAP.

CH A P. III.
OF NITRO NEUTRAL SALTS.

Section 1st.

OF NITRE.

FROM the different results of various experiments, I am led to think that 100 parts of crystallized, but dry nitre, contain 51,8 parts mere alkali, 44 of acid and 4 of water of composition.

HENCE 100 parts tartarin take up 84,96 of real acid with 8,1 of water, and would afford 193 + of dry nitre.

AND 100 grains real nitrous acid take up 117,7 of tartarin, and would afford 227,24 of nitre, by reason of 9,54 of water of composition, which in this case accompanies the acid.

THIS is the best account I am at present enabled to give of nitre, the investigation of the proportion of the acid contained in sp. of nitre, being attended with peculiar difficulties, as much as the acid escapes, when, in its concentrated state, water is added to it, and so much the more as it is more highly mephitized and the temperature

temperature higher. The more it is mephitized the more alkali it appears to saturate, but afterwards the salt extracts oxygen from the air; when melted it also loses part of its oxygen and of its water of composition, but in time seems to regain them.

ACCORDING to Wenzel, 83,5 parts tartarin were saturated by 90 of his strongest acid, and the compound heated to redness weighed 173,5.

THEN 100 grains tartarin should take up 107,78 of his strongest acid (= 87,51 of my real acid) and afford 207,78 of dry nitre.

AND 100 parts nitre contain, by his account, 48,13 of alkali, and 51,87 of his strongest acid, = 42,118 of my real acid.

ACCORDING to Bergman, 49 parts tartarin afford, when saturated with nitrous acid, 100 parts nitre, consequently 100 parts tartarin would afford 204.

LAVOSIER* allows nearly 49 per cent. of alkali and 51 of acid (including water) to 100 grains of nitre.

BERTHOLLET, in the Memoirs of the Royal Academy for 1781, observes, that 480 parts of nitre afford, by distillation, 714 cubic inches of somewhat impure oxygen air, then 100 parts of nitre would

* P. 157 of the English Edition of his Elements of Chymistry.

would afford 148,7 (English measure), these at the rate of 33 per cent. would weigh 49,07 grains, including water lost, which differs but little from my account.

KIER found 22,5 grains dry nitre were saturated by 12,54 grains vitriolic acid, 1,844. Phil. Transf. by my determination 22,5 grains nitre contain 11,655 grains tartarin (for if 100 grains nitre contain 51,8 :: 22,5, 11,655) and 11,655 grains tartarin require 9,61 of real vitriolic acid for their saturation.

Now the sp. grav. 1,844 is intermediate between the tabular gravities 1,8542 and 1,8424, but nearer to the latter; then by the 1st problem its centenary acidity will be found to be 78,58, and if 100 grains of this acid contains 78,58 real acid, 12,54 should contain 9,85, the difference is not quite $\frac{1}{4}$ of a grain. Mr. Kier required 12,54 of this acid, by my determination 12,23 are sufficient, the difference is not $\frac{1}{3}$ of a grain. Phil. Transf.

KLAPROTH found 200 grains of Leucite, treated with marine acid, to afford 70 of muriated tartarin; and that 300 of that stone, treated with nitrous acid, afforded 123 of nitre. Now by Bergman's calculation 100 grains muriated tartarin contains 61 of alkali, therefore 70 grains should contain 42,7.

By my calculation 100 grains muriated tartarin contains 64 of alkali, therefore 70 should contain 44,8 of alkali.

THEN

THEN 100 grains Leucite should contain, per Bergman, 21,35, and by my calculation, 22,4.

By Bergman's calculation there is a *deficit* of 0,27 of a grain, and by mine an excess of 0,77 of a grain. See 2 Klaproth, 50.

BUT with respect to nitre, my calculation has the advantage both over his and Wenzel's, for since 300 grains Leucite afford 123 of nitre, 100 grains of this stone should afford 41. Then by Bergman's account, 41 grains should contain 20,09 of alkali, which leaves a deficit of 2,16 grains; by my determination 41 grains of nitre contain 21,238, which leaves a deficit of only 1,012 grains:

For the calculation stands thus :	{	Silex	53,50	}	Silex	53,50
		Argil	24,25		Argill	24,25
		Tartarin	20,09		Tartarin	21,238
			<hr/> 97,84			<hr/> 98,988

Section 2d.

NITRATED SODA.

IN my former experiment 36,05 grains of mere soda were saturated by 145 of nitrous acid, whose sp. grav. at 60° was 1,2574; this density is intermediate between the tabular sp.

K gravities

gravities 1,2779 and 1,2687, but nearer to the former, and by the solution of the 1st problem will be found to denote 33,8 grains real acid; consequently 145 grains of this liquor contained 49 grains of real acid. The quantity of nitrated foda formed was found by a standard experiment to be 85,142 grains, which is very nearly the sum of the weights of the real acid and mere alkali, as $36,05 + 49 = 85,05$; this trifling difference may be water.

HENCE 100 parts deficcated nitrated foda should contain 57,57 real acid and 42,34 foda.

THEN 100 parts foda should take up 135,71 of real nitrous acid. And 100 parts nitrous acid should take up 73,43 of foda.

SURPRISED at finding no water in this neutral salt, I lately examined its composition by my antient method. I dissolved 200 grains of pure and well deficcated foda, and saturated the solution with 1225 grains of dilute nitrous acid, of which $\frac{1}{4}$ consisted of the concentrated acid 1,416, of which consequently 306,2 were employed; the loss of fixed air was 75 grains, and consequently the quantity of real alkali was 125 grains.

THE sp. grav. 1,416 lies between the tabular gravities 1,417 and 1,412, and by the solution of the 1st problem its centenary quantity of acid will be found to be 53,53; and 100 grains of
this

this acid liquor being diluted with 300 of water, then 400 grains of the dilute acid contain 53,53 real acid; and consequently 1225 grains of it contained 163,9 grains; this quantity therefore was taken up by 125 of foda; if therefore the salt thus formed contained no water the sum of both these quantities should express its weight, namely, $163,9 + 125 = 288,9$ grains; but having very gently evaporated the solution, namely, in a heat not exceeding 120° , and then drying the residuum in a heat of 400° for six hours, I found it to weigh in the evaporating dish (from which I could not separate it without loss) 308 grains, consequently these 308 grains contained 19,1 of water, however it is evident that in a greater heat even these would be evaporated.

AND then very nearly the same proportion of acid and alkali would be found as in the preceding experiment, for $308 - 19,1 = 288,9$, and if 288,9 grains contain 125 of alkali, 100 grains of the nitrated foda should contain 43,27, and consequently 56,73 of acid; and allowing 19 grains of water in 308 of this salt dried at 400° , then 100 grains nitrated foda should contain 40,58 of foda, 53,21 of real nitrous acid, and 6,21 of water.

AND 100 grains mere foda saturated with nitrous acid should afford 246,42 of nitrated foda dried at that heat. And 100 grains real nitrous acid saturated by foda should give 188 nearly of nitrated foda dried as above.

BERGMAN, Vol. I. p. 20, allows to 100 parts soda very nearly the same quantity of real nitrous acid as I do, namely, 135,5 parts.

HAVING re-dissolved the above 308 grains and exposed the solution to spontaneous evaporation, I found the crystals dried at 70° to weigh 317 grains; hence this salt contains 2,8 per cent. of water of crystallization, but in a strong heat it would lose much more.

THOUGH Wenzel's determinations seemingly differ considerably from the foregoing, yet on a closer inspection the difference will be found not greater than the usual imperfection of weights and weighing, and the varying nature of the acid may admit.

HE found 71,5 grains mere soda saturated with nitrous acid to afford 190,75 of thoroughly desiccated nitrated soda, and hence concluded that it contained no water, and consequently 190,75 grains of this salt to contain 71,75 of alkali and 119,25 of real acid.

HENCE 100 grains of this salt should contain 37,48 of alkali and 62,52 of acid; it is plain then that this acid contained the 6,21 grains of water which I found in 100 parts of this salt, for if we add 6,21 to the quantity of acid I ascribe to 100 parts of this salt, we shall find very nearly Wenzel's weight of acid, for $53,21 + 6,21 = 59,42$.

ACCORDING

ACCORDING to Wenzel, then, 100 grains mere foda take up 166,7 of this aqueous acid, and should afford 266 of nitrated foda thoroughly deficcated; and 100 grains of the aqueous acid should take up 59,9 of foda.

FROM the experiment on nitrated foda Wenzel deduces the strength of his sp. of nitre, which being the same as he employed in his subsequent numerous experiments it is important to discover.

As he saturated 71,5 grains foda with 347 grains of this sp. of nitre and found the foda to take up 119,25 of what he thought the strongest nitrous acid, he concluded that 240 grains of it contained 82,5 of the strongest acid, and consequently 100 grains of it should contain 34,375 of his strongest acid. Now to compare the quantity of his real acid in his sp. of nitre with that which I judge his to possess, I must observe that to saturate 71,5 grains mere foda, 96,933 grains of my real acid would be requisite, and consequently that 347 grains of his spirit of nitre contained no more; therefore 240 grains of his spirit of nitre contained but 67,04 of my real acid, and 100 grains of it contained 28 of my real acid; the difference is water contained in his strongest acid. Then 1000 grains of his strongest acid is only equal to 812,6 of my real acid; the remainder *v. z.* 187,4 being water contained in his strongest acid.

MORVEAU

MORVEAU saturated 485 grains of crystallized soda (= 104,66 of mere soda) with 545 grains of spirit of nitre, whose sp. grav. at 4° of Reaumur (= 41° of Fahrenheit) was 1,2247, which at 60° of Fahren. would be 1,219, and this by my calculation contains about 27,29 per cent. real acid; consequently 545 grains contained 148,73; then 100 grains mere soda should take up 142 of real nitrous acid. 2d Old Mem. Dijon 184.

LAVOSIER also saturated a given quantity of soda with nitrous acid, but as there was an excess of acid no stress can be laid on his experiment.

I found nitrated soda to attract moisture in a moderate degree.

NITRATED BARYTES.

As barytic earth cannot well be dissolved in nitrous acid without the assistance of heat, I was obliged to attempt the analysis of this salt by indirect methods, namely, precipitation by crystallized soda and vitriolated tartarin.

THE soda I employed contained 15 per cent. of fixed air, and 21,5 of mere alkali; and 100 grains of aerated barytes ignited contains about 21,5 of fixed air.

Now I found that 100 grains of crystallized nitrated barytes were precipitated by 105 nearly of this soda, and that the earth
after

afteredulcoration, desiccation and ignition, weighed 70,25 grains nearly; but at the rate above-mentioned these 70,25 grains are reducible, deducting the fixed air to 55,10 of pure barytic earth.

ON the other hand 108 grains of crystallized soda contain 23,22 grains of mere soda, and these we have already seen are capable of taking up 31,41 of real nitrous acid, therefore by this experiment 100 grains of crystallized nitrated barytes contain 31,41 of acid and 55,10 of earth; the remainder then is water of crystallization, = 13,49 grains.

AGAIN, 100 grains of crystallized nitrated barytes were dissolved in 2400 of water, and precipitated by the gradual addition of a solution of vitriolated tartarin; the precipitate which was slowly and difficultly formed and collected weighed after ignition about 88 grains; these (at the rate of 33,33 per cent.) contained 29,33 of real vitriolic acid, and consequently 58,67 of mere earth.

TAKING a mean, then, of these two experiments, 100 grains of nitrated barytes contain 56,88 grains of mere earth.

LASTLY, 308 grains of native aerated barytes dissolved in 240 of nitrous acid, whose sp. grav. was 1,451, diluted with 5 times its weight of water in a gentle heat afforded 384 grains of crystallized nitrated barytes, besides a small residuum,

Now

Now this acid contains 58 per cent. real acid, and consequently 240 grains of it contained 139,2 of real acid; and if 384 grains of the crystals contain 139,2, then 100 grains should contain 36,25. But it must be considered that some was contained in the mother liquor, some in the crystals that were not washed, but dried on filtering paper, and some was dispersed by the heat applied.

THIS experiment also gives some, though not an accurate information of the proportion of earth in nitrated barytes, for 308 grains of aerated barytes (at the rate of 21,5 per cent.) contain 66,22 of fixed air, and consequently 241,78 of mere earth. Supposing then 384 grains of nitrated barytes to contain this quantity of earth, 100 grains of this salt should contain 62. But this supposition is inadmissible by reason of the losses just mentioned.

UPON the whole we may state the centenary proportion of this salt at 57 of earth, 32 real acid, and 11 of water.

HENCE 100 grains barytic earth take up 56 of real nitrous acid, and should afford 175,43 of nitrated barytes. And 100 grains real nitrous acid should take up 178,12 grains of barytic earth, and should afford 312,5 of nitrated barytes.

100 grains of this salt lost only $\frac{1}{2}$ a grain of its weight by exposure to a heat of 300° for half an hour. It is also difficultly soluble. Its solution when saturated does not redden Litmus.

NITRATED

NITRATED STRONTHIAN.

100 grains of perfectly crystallized nitrated stronthian, dissolved in 480 of water, were precipitated by about 107 of crystallized soda, containing 16 per cent. of fixed air and 21,5 of mere alkali, the precipitate, after ignition, weighed 53,25 grains, and contained 17,04 of fixed air, and consequently 36,21 of mere earth.—Also the 107 grains of soda (at the rate of 21,5 per cent.) contained 22,9 of mere alkali, which (at the rate of 135,71 per cent.) took up 31,07 of real nitrous acid; then by this experiment 100 grains crystallized nitrated stronthian contain 36,21 of earth, 31,07 of acid, and 32,72 of water.

THEN 100 grains of pure stronthian earth take up 86 nearly of real nitrous acid, and should afford 276 of crystallized, or about 92 of thoroughly desiccated nitrated stronthian.

AND 100 grains real nitrous acid should take up 116,5 of mere stronthian earth, and afford 321 of crystallized, or 107 of thoroughly desiccated nitrated stronthian.

Section 3d.

NITRATED LIME.

IN my experiment 136 grains Carrara marble were saturated by 400 of nitrous acid, whose sp. grav. was 1,2754, and which conse-

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quently contained (at the rate of 33,59 per cent.) 134,36 real acid. The 136 grains Carrara marble contained (at the rate of 55 per cent.) 74,8 of lime.

CONSEQUENTLY 100 parts lime take up 179,5 of real nitrous acid, and 100 parts real nitrous acid take up 55,7 of lime.

LAVOSIER dissolved 972 grains of slacked lime, dried in a heat of about 600°, in 3456 grains of nitrous acid, whose sp. grav. was 1,2989, and consequently contained (at the rate of 36,7 per cent.) 1268 grains real acid; from the 972 grains lime we must deduct (at the rate of 28,7 per cent. water absorbed in the slacking) 268,9 of water, and also 35 grains of fixed air, absorbed while slacking and drying, there remain then 668 of mere lime, and these took up 1268 of real acid, then 100 grains of lime would take up 190 of real acid. 1 Lavosier, 198. Perhaps the difference arises from my computing the quantity of real acid from a specific gravity taken at 60°, whereas his might have been taken at a higher degree.

BERGMAN found 100 grains of nitrated lime, *well dried* (that is dried in air) to contain 32 of lime; by the above analogy the proportion of the other two ingredients may be found, for since 100 parts lime take 179,5 of real acid, 32 should take 57,44, consequently the remainder, viz. 10,56 are water; if the nitrated lime could be perfectly dried, it would contain about 36 per cent. of lime and 64 of real acid.

ACCORDING

ACCORDING to Wenzel 122,66 grains of lime take up 240 of his strongest acid, consequently 100 of lime would take up 195,64 of such acid, but this quantity is equivalent to only 159 of my real acid, this difference I cannot account for.

Section 4th.

NITRATED MAGNESIA.

By my experiment 100 parts mere magnesia require 210 of real nitrous acid for their saturation.

AND 100 grains real nitrous acid take up 47,64 of mere magnesia. 100 grains crytallized nitrated magnesia contain 46 real acid, 22 magnesia, and 32 of water, as I found.

ACCORDING to Wenzel 77 grains of the magnesia he employed contained but 32,13 mere earth, and yet required 240 of his sp. of nitre for their saturation, which sp. of nitre, by my calculation, contained but 67,2 real acid, and consequently 100 grains mere magnesia would require 209 real nitrous acid; by his own calculation 240 of his sp. of nitre contained 82,5 of his strongest nitrous acid, and consequently 100 grains mere magnesia should take up 256 of such acid, = 207,87 of my real acid.

ACCORDING to Fourcroy, 4 An. Chy. 214, 150 grains aerated magnesia, containing 48,66 per cent. mere magnesia, and consequently in all 73 grains, were saturated by 222 grains of nitrous acid, whose sp. grav. appears to have been 1,5298, of which 100, by my table, contain 69,88 real acid, and consequently 222 contain 155; and if 73 grains mere magnesia take up 155 real acid, 100 grains mere magnesia should take up 212.

CHAP. IV.

OF MURIATIC NEUTRAL SALTS.

Section 1st.

OF MURIATED TARTARIN.

IN my last paper I have stated that 86 grains of mere tartarin were saturated by 254 grains of muriatic acid, whose sp. grav. at 60° was 1,1466; this is extratabular, but intermediate between the tabulated specific gravities 1,147 and 1,1414, but nearer to the higher, and its centenary acid contents will be found by the 1st problem to be 19,06; consequently 254 grains of this acid liquor contained 48,412 real acid; the sum of the acid and alkaline parts then amounts to $48,412 + 86$, = 134,412 of muriated tartarin; and since 134,412 of this salt contained 86 of alkali, 100 parts of the dry salt should contain 64 nearly of tartarin, and the remainder or 36 parts are real marine acid.

HENCE 100 grains tartarin take up 56,3 of real marine acid, and should afford 156,3 of well dried muriated tartarin. And 100 grains real marine acid should take up 177,6 of mere tartarin, and afford 277,6 of deficcated muriated tartarin.

WENZEL

WENZEL found 83,5 grains of tartarin to afford him 129 of muriated tartarin, consequently 100 parts of this salt should contain 64,7 of alkali, and 35,3 of acid, and 100 parts tartarin should take up 54,491 of real acid, and afford 154,491 of muriated tartarin, all which determinations differ very little from mine, and afford no inconsiderable proof of the accuracy of the table.

HENCE we may deduce the quantity of real acid in Wenzel's sp. of salt and its sp. gravity.

By his own account 202 grains of his sp. of salt contained 45,5 of his strongest acid, consequently 100 grains of it should contain 22,52, and 240 grains of it 54, and its sp. gravity about 1,174.

By my calculation 202 grains of his sp. of salt contained 46,44 of my real acid, and 100 grains of it contained nearly 23 of my real acid, and 240 of it contained 55,17, and its sp. gravity should be about 1,176.

ANOTHER proof of the accuracy of my determinations will be found in the 2d §.

KLAPROTH's determination agrees fully with mine, for to 116 grs. of sylvian he ascribes 42 of concentrated muriatic acid, consequently 100 grains of sylvian should contain 36,2. 1 Klapr. 134.

Section

Section 2d.

COMMON SALT.

It has been seen in my last paper that 30,05 grains of mere soda were saturated by 129 grains of muriatic acid or sp. of salt, whose sp. gravity in the temperature of 60° was 1,1355; this by the table contains about 17,5 real acid per cent. consequently 129 grains of it contained 22,07 grains real acid, if therefore the neutral salt here formed contained nothing else but mere soda and real acid, its weight should be $30,05 + 22,07 = 52,12$. Yet by the last experiment it appeared that the weight of the salt thus formed amounted to 56,74 gr. the surplus 4,62 grains must therefore have been water, and since 56,74 grains of common salt contain alkali, real acid and water in the above proportions, 100 grains of common salt (well dried and deprived of the water interspersed between its pores) must contain 52,96 soda, 38,88 real acid, and 8,16 water of composition that always accompanies the acid when this salt is formed, and therefore must in all other ways of examining the composition of this salt, have been confounded with it. In this sense therefore I may say that 100 parts common salt contain in round numbers 53 parts alkali and 47 of acid.

HENCE 100 parts mere soda take up 73,41 of real marine acid, or 88,74 of the aqueous acid, and then afford 188,74 of common salt. And 100 parts of the aqueous acid should take up 112,688
of

of foda, and afford 212,688 of common salt, and 100 grains real marine acid should take up 136,31 of foda, and afford 257,2 of common salt.

100 grains of the aqueous acid contain 15,33 of water.

ACCORDING to Wenzel 131,5 of ignited common salt contain 71,5 of alkali, and 60 of his strongest marine acid; consequently 100 grains common salt should contain 54,3 of alkali, and 45,7 of that acid. And 100 parts mere foda should afford 184 nearly of ignited common salt. This statement differs very little from mine, and from Weigleb's still less, for he found 100 parts common salt to contain 53,5 of alkali, and 46,5 of acid, and 100 parts foda should take up 87,5 of acid, and afford 187,5 of common salt.

BUT Mr. Bergman's statement differs widely from the foregoing, both Wenzel and I have found the alkaline part to exceed the acid, he on the contrary found the acid to exceed by much the alkaline, for to 100 parts common salt he assigns 52 of acid, 6 of water and only 42 of alkali. From the great respect I have ever entertained for this excellent man, this circumstance always gave me much uneasiness. To investigate the truth by direct experiment otherwise than was always done appeared difficult. I therefore endeavoured to discover it by an *indirect* experiment, namely, by finding how much caustic foda might be obtained from the decomposition of a given quantity of common salt, this
decomposition

decomposition I effected by tartarin, but the exact separation of the soda from the sylvian was so difficult that I despaired of obtaining satisfaction in that way: luckily, however, a more patient and skilful experimenter, Mr. Hahneman has since performed this experiment, and found that 11 parts mere tartarin were requisite to separate 7 of *mere* soda from common salt.* We may therefore now examine with which of the two opposite statements this proportion is best suited.

By my determination 7 grains soda enter into the composition of 13,21 of common salt, and this quantity of common salt contains also 5,13 grains real acid, which must be taken up by the tartarin to set the 7 grains of soda free. Now since 100 parts tartarin take up 56,3 of real marine acid, 9,12 of tartarin should take up 5,12 of this acid, which falls short of Hahneman's result by 1.88 grains. But it is well known that somewhat more of any divellent agent must be applied to effect an *intire separation* of any principle than would be necessary to saturate that principle if it were in a free disengaged state.

By Bergman's determination 7 grains of soda enter into the composition of 16,66 of common salt, and this quantity of common salt contains also 8 of real marine acid, now, as according to him 100 parts tartarin take up 51,5 of the strongest or real marine acid, 15,53 would be requisite to take up 8 of that acid, which exceeds Hahneman's result by 4,53 grains, whereas by the above reason it should rather fall short of it.

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BUT

* 2 Chy. An. 1797, p. 396.

BUT there are two other experiments which set the inaccuracy of his determination in a still clearer light, the one executed by Mr. Wolfe, and the other by Dr. Black †.

MR. WOLFE found that 120 parts muriated silver or luna cornua, when decomposed by tartarin, afforded 55 grains of sylvian or muriated tartarin; these 55 grains therefore contained all the acid that existed in 120 of muriated silver. Now Dr. Black found that 235 grains of muriated silver contain all the acid that exists in 100 grains of common salt, and consequently 120 grains of the muriated silver contain all the acid that exists in 51,06 of common salt, whence it follows that 55 grains of sylvian and 51,06 of common salt contain the *same quantity of acid*, since the first received and the latter gave out all the acid that exists in 120 parts muriated silver.

WE may now see in which of the 2 different statements this equality is found, or whether in neither or in both.

1st. ACCORDING to Bergman 100 grains of muriated tartarin contain 31 of real acid, then 55 grains of that salt should contain 17,05.

AGAIN, 100 grains of common salt contain by his statement 52 of real acid, then 51,06 of this salt should contain 27,55; these quantities are evidently very distant from an equality.

2d.

† Phil. Transf. 1776, p. 611. 3 Edinb. Transf. 116.

2d. By my statements 100 parts sylvian contain 36 of real acid, then 55 parts of this salt should contain 19,8; also 100 parts common salt contain 38,88 real acid, then 51,06 parts of this salt should contain 19,85.

Section 3d.

MURIATED BARYTES.

THE proportion of ingredients in this salt may be investigated from the following facts:

1st. KLAPROTH found that 73 grains of aerated native barytes (which contained an inconsiderable proportion of stronthian) saturate 100 grains of muriatic acid, whose sp. grav. was 1,140 diluted with 200 grains of water, and that 100 grains of aerated barytes contain 22 of fixed air, 2 Chy. An. 1793, p. 195 and 196, and 1 Klapr. 269, therefore 73 grains of aerated barytes contain 56,94 of barytic lime.

2dly, He found that 56,59 pure aerated barytes dissolved in this acid afforded 6850 of crystallized muriated barytes. 2 Klapr. 84.

THEN 100 grains of aerated barytes, or 78 of mere barytes, would give 21,04 of muriated barytes. And 100 grains of mere barytic earth should give 155 nearly of crystallized muriated barytes.

ACCORDING to Fourcroy, 4 An. Chy. 71, 100 grains native barytes afford but 112 of desiccated muriated barytes; yet Pelletier

tells us, that 100 grains native aerated barytes afforded him 138 of crystallized muriated barytes, but most probably it retained some of the mother liquor.

HENCE I deduce, 1st, that as 100 grains muriatic acid, 1,140 contain 18,11 real acid, 56,94 of barytes took up that quantity.

CONSEQUENTLY 100 *grains mere barytic earth* take up 31,8 of real marine acid, and afford 155 of crystallized muriated barytes.

AND 100 *grains real marine acid* should take up 314,46 of barytes.

WE may also remark, that the muriatic acid whose density is 1,140, being mixed with twice its weight of water, will have its sp. grav. 1,0427 which is nearly the same as that which Fourcroy found best adapted to such solution, namely, 1,0347; and perhaps if the temperature were equal would approach each other still more nearly. It appears then that the real acid should be accompanied with 16 times its weight of water.

2dly, IT follows, that 121,04 parts crystallized muriated barytes contain 78 earth, 24,8 acid, and 18,24 water, consequently 100 *parts of the crystallized salt* contain 64,44 earth, 20,45 acid, and 15,06 water.

AND 100 *grains of the desiccated* contain about 70 of earth, 22 of acid, and 8 of water.

(PER

(PER Crawford, quoted by Schmeiffer in Phil. Transf. 179, 421, muriated barytes is nearly as soluble in hot as in cold water, and three times less soluble than muriated stronthian.)

To confirm this conclusion I must add, that having precipitated a solution of 100 grains of crystallized muriated barytes by a solution of nitrated silver, I found the precipitate duly dried to weigh 118 grains, which as we shall presently see argues the presence of 19,51 of real marine acid. I also found that 100 parts muriated barytes exposed to a heat of 300° for two hours, lost 16 grains of water of crystallization, hence we may rate in round numbers the proportion of ingredients in this salt, at 64 of earth, 20 of acid, and 16 water of crystallization.

Section 4th.

MURIATED STRONTHIAN.

KLAPROTH observed, that 55 grains of native mild stronthian saturated 100 of marine acid; whose sp. grav. was 1,140, this being diluted with 50 grains of water, 100 grains marine acid of this sp. grav. contain, computing from my table 18,11 grains of real acid, and 55 grains mild stronthian, (at the rate of 69 per cent.) contain 37,95 of mere earth.

HENCE.

HENCE I conclude, that 100 grains mere stronthian earth take up 47,79 of real acid (since 37,95 take 18,11 of real acid) and would afford, as we shall presently see, 254,84 of crystallized muriated stronthian, or 147,79 of desiccated stronthian*.

AND 100 grains real marine acid enter into the composition of 209 grains of desiccated stronthian, or of 360 of the crystallized.

AGAIN, Dr. Hope found, that 100 grains *crystallized muriated stronthian* contain 42 of *water of crystallization*, and consequently 58 of desiccated which contain earth and acid in the proportion above mentioned (or 100 earth to 47,79 acid) that is, 39,24 of earth and 18,76 of acid, this proportion agrees very exactly with that observed by Pellitier†, for he found 100 grains of native aerated stronthian (which contain 69 of earth) to afford 176 of crystallized muriated stronthian.

AND since, in Dr. Hope's experiment, 39,24 of this earth afforded 100 grains of muriated stronthian, 69 should afford 175,8. Some experiments however of Mr. Lowitz vary considerably from the above statements, it appeared to him that in muriated stronthian the quantity of acid exceeded that of earth in the proportion of 54 to 46‡; if so, 100 grains of muriatic acid of the sp. grav. 1,140 should contain 44,54 of real acid, for it took up 37,95 of
earth

* 2 Chy. An. 1793, p. 194. † 21 An. Chy. p. 128. ‡ 1st. Chy. An. 1796, p. 128, 129.

earth in Klaproth's experiment already quoted, which is inconsistent with the proportion of real acid. I have found in muriatic acid in a multitude of experiments, and contrary to all analogy, as we see that by barytes and fixed alkalis betwixt which this earth undoubtedly stands, take up less than their own weight of real marine acid: it is also contradicted by Pellitier's experiment, for since 100 grains native aerated stronthian contain 69 of earth, these at the rate of 46 to 54 should take up 80 grains of real muriatic acid, and the sum of both would be 149 grains: and since by Dr. Hope's experiment 58 grains of united earth and acid take 42 grains of water of crystallization, 149 grains should take 107; and hence instead of 176 grains of crystallized muriated stronthian we should have 256 grains from 100 of aerated stronthian.

KLAPROTH informs us, that from a solution of 100 grains of aerated stronthian in muriatic, precipitated by the addition of concentrated vitriolic acid, as long as any precipitate appeared, he obtained no more than 114 grains of vitriolated stronthian, and that dried only in air*; whereas the precipitate should amount, if the whole of it were obtained; to 118 grains; for since 58 grains of this earth, as he elsewhere relates, † afford 100 of vitriolated stronthian, 69 should afford 118; it is plain therefore that the marine

* 2 Chy. An. 1793, p. 200.

† 2 Klapr. p. 97.

rine acid retained some, or that a sufficiency of the vitriolic acid was not added. This earth is not therefore a proper test of vitriolic acid, at least not as proper as the barytic.

To obtain a less circuitous proof of the proportion of ingredients in 100 parts of this salt, I precipitated a solution of 100 grs. of crystallized muriated strontian by mild soda; the precipitate after ignition weighed 56,75 grains, but these being dissolved in marine acid gave out 17 grains of fixed air, and therefore contained only 39,75 of mere earth.

2dly. I precipitated a solution of another 100 grains of this crystallized salt by a solution of nitrated silver, and found the precipitate duly dried to weigh 110 grains, a weight which indicates the presence of 18,19 grains real marine acid. The weight of the 3d ingredient, namely water, must therefore amount to 42,06 grains nearly, as Dr. Hope has stated.

HENCE we may rate the proportion of ingredients in 100 parts of this salt at 40 of earth, 18 of acid, and 42 of water. And to 100 parts of the desiccated salt we may allow about 69 of earth and 31 of acid.

HENCE 100 *parts strontian earth* take up 45 or more, exactly 46 of real marine acid, and should *afford* 250 of crystallized, or 145 of desiccated muriated strontian. And 100 *parts real marine acid*

acid should take 222, or more exactly 216,21 of stronthian earth, and afford 540 of crystallized, or 313,5 desiccated muriated stronthian.

Section 5th.

MURIATED LIME.

IN my experiment already mentioned 158 grains of powdered Carrara marble were saturated by 402 of muriatic acid, whose sp. grav. was 1,1355, which contained 17,5 per cent. real acid; therefore 402 grains of it contained 70,55 real acid. The 158 grains marble (at the rate of 53 per cent.) contained 83,74 of lime. Then 83,74 grains lime took up 70,55 of real marine acid. To effect a saturation a heat of 160° was employed towards the end of the solution.

HENCE 100 grains of lime would saturate 84,488 of real marine acid. And 100 grains real marine acid would saturate 118,3 of lime.

IN Wenzel's experiment the acid was not saturated, and hence the result differs from that of mine. To 240 grains of his sp. of salt he added 120 grains of fragments of purified oyster-shells (which, as we have already seen in treating of selenite, contained 52,8 per cent. of lime,) and at the latter end exposed them

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to

to a gentle heat, and when no sensible solution appeared he separated what remained undissolved, and found that after washing and drying it, it weighed 19,625 grains; hence he concluded that 100,375 grains of these shells were dissolved; but then he had no reason to think the acid was saturated, or that in a longer time it would not take up more, especially as the shells were not in a fine powder, nor did he apply any test as I did. Having evaporated the solution to dryness and heated the dry mass to fusion, he found it to weigh whilst still red hot 106,125 grains.

THIS shews the solution not to have been saturated, for 100,375 grains of the shells contained 53 of lime, and the 240 grains sp. of salt contain 54 of real acid by his own account; therefore, as saturated muriated lime loses no acid in a melting heat, the salt should weigh even by his estimation 107 grains, and by my calculation 112 grains; the remainder therefore of the unsaturated acid was expelled by the heat of fusion.

ACCORDING to him 100 grains lime should take up 102 grains of the strongest marine acid.

IT must be remarked, also, that this salt though in a melting heat still retains some water, and Wenzel's experiment shews how much; for by my determination 53 grains lime take up only 44,75 of real acid; and the sum of the ingredients in Wenzel's experiment amounts only to 97,75 grains; yet he found the weight 106,125; then 8,375 grains were water.

THEN

THEN 100 grains muriated lime, weighed red hot, contain nearly 50 of lime, 42 of acid and 8 water.

BERGMAN agrees with me so far as stating the proportion of lime in this salt to be superior to that of acid; to 100 parts of this salt he assigns 44 of lime and 31 of acid, but the proportion of acid is higher, for to 44 of lime 37 of acid appertains, by the proportion above stated then that of water is 19.

Note. His salt was weighed at far a lower temperature than Wenzel's, and hence the quantities but not the proportions in 100 grains of it are altered, as it powerfully attracts water.

Section 6th.

MURIATED MAGNESIA.

THE proportions of acid and basis in this salt are difficultly determined, as it powerfully attracts moisture and easily loses its acid if strongly heated, and without such heat will retain much water.

IN my experiments it appeared that 100 grains mere magnesia took up 215,8 of standard, or 111,35 of real marine acid.

AND 100 grains real marine acid take up 89,8 of mere magnesia.

KLAPROTH * found 420 grains of muriated magnesia evaporated to dryness to contain 290 of magnesia; as it was precipitated by soda he probably meant mild magnesia, which generally contains but 0,45 of earth; if so, 290 contained but 130,5 of mere magnesia; consequently 100 grains of muriated magnesia gently but sensibly dried should contain 31,07 mere magnesia, and this by my computation should take up 34,59 of real acid. The remainder is therefore water.

WENZEL's experiments accord with mine with respect to the superiority of the proportion of earth to that of acid in a given weight of muriated magnesia. According to him 100 grains of mere magnesia take up 122 of real marine acid; but by my computation of the quantity of real acid in his sp. of salt, *v. z.* 23 per cent. allowing his mild magnesia 45 per cent. of earth, 100 grains of it should take up 115,8 real muriatic acid.

BERGMAN's results differ from these very widely, for according to him 41 grains mere magnesia take up only 34 of the strongest marine acid.

Section

* 1 Klapr. 369.

Section 7th.

MURIATED SILVER.

It is now well known from the experiments of Margraff, Bergman, Klaproth, Wolfe, Wenzel, &c. to which I need not add my own, that 100 grains of muriated silver contain very nearly 75 of silver when dried in a heat of 80° , or 75,235 when heated more but not fused, as in Wenzel's and Wolfe's experiments; but it must not be inferred that the remaining 25 grains are mere marine acid, for silver dissolved in nitrous acid takes up 10,8 per cent. of oxygen; therefore 75 grains of it take up 8,1, which subtracted from 25, leaves the quantity of acid 16,9; or if the muriated silver were much heated, the acid and oxygen would amount only to 24,76; and deducting the oxygen, the acid singly would be 16,6 grains; this agrees exactly with Wolfe's experiment, for he found as already said that 120 grains of this metallic salt decomposed by tartarin afford 55 of muriated tartarin. Now 120 grains contain by this computation 19,92 of real acid; and as 100 grains muriated tartarin contain 36 of real acid, 55 grains of it should contain 19,8; the difference is insignificant.

HENCE 100 grains silver take up 22,133 of real marine acid, and afford 133 of muriated silver by the addition of oxygen.

AND 100 grains real marine acid unite to 451,87 of silver, and afford 602,4 of muriated silver.

100 grains pure crystallized common salt precipitate from a solution of nitrated silver 233,5 grains of muriated silver by Klaproth's, 235 by Dr. Black's, and 237 by Arrhenius's experiments*; Dr. Black's is a medium between both; the difference arises only from the degree of deficcation.

100 grains of muriated tartarin should produce 216,86 of muriated silver.

Section 8th.

MURIATED LEAD.

THIS salt may be obtained in two states, either in acicular crystals or thoroughly deficcated. The proportion of ingredients in each I deduce from the following facts:

1st. KLAPROTH having dissolved 100 grains lead in dilute nitrous acid, and precipitated the lead by caustic tartarin, found the precipitate sharply dried until it began to grow yellow, to weigh 115 grains. 1 Klaproth, 274.

2d. HAVING precipitated a solution of 100 grains of lead in nitrous acid by dropping muriatic acid as long as any precipitate appeared, and evaporated the whole to dryness in a sand heat, he found the muriated lead to weigh 133 grains. Ibid.

3d.

* Mem. Stock. 1785.

3d. He also found that 22,5 grains of crystallized acicular muriated lead, well drained and dried by exposure to the air, contained 16 grains of metallic lead, therefore 100 grains of such crystals should afford 71,11 of metallic lead.

FIRST, to these facts I must farther add, that in muriated lead, whether crystallized or desiccated, the lead is in a calcined state.

HENCE I infer, that since 100 grains of metallic lead give 133 of calx of lead, the 71,11 grains of metallic lead in 100 parts crystallized muriated lead amount to 81,77 of calx of lead. The calx, including not only the metallic lead, but also oxygen and water, as we shall presently see; the remainder therefore is real marine acid, amounting to 18,23 grains.

AGAIN, as 133 grains of the thoroughly desiccated muriated lead contain 100 of metallic lead, 100 grains of this muriated lead must contain 75,12, but 75,12 metallic lead form 83 of calx; the remainder therefore must be real marine acid = 17 grains.

THESE conclusions are farther confirmed by the experiment of Mr. Wolfe. Phil. Transf. and 10 Roz. 370. Having decomposed 120 grains of muriated lead dried by exposure to the air by a sufficient quantity of tartarin, he found them to produce 61 grains of muriated tartarin. Therefore both the 120 grains muriated

riated lead and the 61 grains of muriated tartarin should contain the same quantity of real marine acid. Now if 100 grains muriated lead dried in air contain 18,23 real acid, 120 grains of it should contain 21,87 real acid.

AND since 100 grains muriated tartarin contain by my former determination 56 grains real acid, 61 grains of this salt should contain 21,96; the difference is only 0,09 of a grain.

As to the 115 grains calx of lead produced in the precipitation of a solution of 100 grains of lead in nitrous acid by caustic tartarin, I have already shewn in the 2d vol. of my Mineralogy, p. 497, that 100 parts lead, when dissolved in nitrous acid, take up 5,8 of oxygen*, therefore the remainder is water, = 9,2 grains.

HENCE 100 parts metallic lead take up about 25,63 of real marine acid, and afford 140,62 of crystallized muriated lead, or 133,12 of the deficcated.

AND 100 grains real marine acid unite to 394,06 of metallic lead, and afford 548,64 of crystallized muriated lead.

AND

* Fourcroy, 2 An. Chy. 213, states the quantity of oxygen at 12,5 in 100 of muriated lead, but this is contradicted by the experiment of Mr. Wolfe, &c. He most probably means the muriated lead formed in the solution of a calciform ore.

AND 100 parts crystallized muriated lead contain 81,77 calx of lead (= 71,11 metallic lead,) and 18,23 of real marine acid.

AND 100 grains thoroughly deficcated muriated lead contain 83 calx of lead (= 75,12 metallic lead,) and 17 of real marine acid.

ACCORDING to Wenzel, 100 grains metallic lead should afford 137,5 of deficcated muriated lead; he probably dried it somewhat less than Klaproth had done. The proportions of lead and acid he could not well determine, the existence and proportion of oxygen not being known when he wrote.

Note. The quantity of metallic lead obtained from 100 parts crystallized muriated lead by fusion with black flux is much smaller than that above stated. (see 1 Klapp. 171,) as much is retained by that flux. Yet see 3 Westrumb. Physical and Chem. Abhandl. 383.

OF AERATED VOL-ALKALI AND AMMONIACAL SALTS.

THE former experiments which I made with a view of ascertaining the proportion of ingredients in these salts were defective in several respects:

1st. For want of a due estimate of the quantity of mere vol-alkali in a given quantity of aerated alkali, the substance to be saturated with the three other mineral acids. Dr. Priestly's experiments, the basis of the estimate I then formed, not exhibiting the temperature and pressure of the atmosphere when the volumes of fixed and alkaline airs were combined, afforded an opportunity for forming rather an approximation than an accurate determination of their several weights.

2d. I WAS not then aware of the difficulty of finding the exact point of saturation of the aerated vol-alkali with the mineral acids; a difficulty however mentioned by Macquer*, and so great that Du Hamel judged it impossible to vanquish it†. Wenzel very sagaciously absorbed the excess of acid by oyster shells, but in my mode of experimenting this test could not be applied; hence there was an excess of acid in all of them. These errors induced me to analyze rather than compose these salts.

OF AERATED VOL-ALKALI.

By distilling 100 grains of aerated vol-alkali with 300 of dry slacked lime in a pneumatic apparatus and a sand heat I obtained 129 cubic inches of alkaline air, barometer 30.2, and thermometer at

* Macquer's Elem. 389, English. † Mem. Par. 1735, p. 664, in 8vo.

at a medium 62,5. 100 grains of alkaline air weigh 18,16 grains, as I have shewn in a former treatise, barometer 30, thermometer 61. Then at that barometrical height 129 cubic inches would become 130; but as the heat in the present experiment exceeded 61, the expansion resulting from it must be subtracted; and according to Mr. Morveau, 2 An. Chy. a volume of this air at 32° being taken as 1 becomes at 77° 1,2791, and consequently gains 0,0062 by each intermediate degree, consequently the volume of this would at 61 be only 129,1; its weight therefore is nearly 24 grains. This salt contained 52 per cent. of fixed air, consequently its ingredients were 52 grains fixed air, 24 of mere alkali, and 24 of water.

The proportion of vol-alkali in aerated vol-alkalis vary, increasing or decreasing with the proportion of fixed air they contain.

MR. CAVENDISH in the Philosophical Transf. for 1766, p. 169. found that 1643 grains of aerated vol-alkali, containing 53,8 per cent. of fixed air, saturated the same quantity of marine acid as 1680 of another parcel, which contained but 52,8 per cent. of fixed air.

HENCE the quantities of mere alkali in each were reciprocally as 1680 to 1643, and these are nearly to each other as 53,8 to 52,8; and as the aerated vol-alkali that contained 52,8 per cent. of fixed air contained 24 per cent. of mere vol-alkali; that which contained 53,8 per cent. of fixed air should have contained 24,83 per cent.

HENCE the *proportion of fixed air in aerated vol-alkalis* is to that of mere alkali in those salts as 13 to 6, and the remainder is water of composition.

WENZEL, p. 100, also perceived that the proportion of mere alkali in aerated vol-alkali was very small, and states it nearly as low as I do; for to 240 grains of this salt, containing 53,75 per cent. of fixed air he ascribes 129 of fixed air, 31,125 of water, and consequently 79,875 of mere alkali. Hence 100 grains should contain 53,75 fixed air, 33,28 of alkali and 12,97 of water.

COMMON SAL AMMONIAC.

By distilling in a pneumatic apparatus and a sand heat, 100 grains of sublimed sal ammoniac and 300 grains of quick lime, I found it to yield as much alkaline air as amounted to 25 grains, with some few drops of water; the remainder of the water being probably detained by the lime or by the muriated lime which is known to retain water most obstinately.

By treating 100 parts of this salt in solution with a solution of nitrated silver, I found it to afford 258,5 of muriated silver heated to fusion, and consequently to contain 42,75 of real marine acid.

HENCE

HENCE 100 parts of this salt contain 42,75 of real marine acid, 25, or making allowance for losses, 28 of mere vol-alkali, and 29,25 of water of crystallization and composition.

HENCE 100 parts mere vol-alkali take up 152,68 of real marine acid, and should afford, if there were no loss, 357,14 parts of sublimed sal ammoniac. And 100 parts marine acid take up 65,4 nearly of mere volalkali, and should afford 233,9 parts of sublimed sal ammoniac; but in subliming sal ammoniac there is always some loss.

MR. Cavendish, in the Philosophical Transactions for 1766 tells us, that 168 parts aerated vol-alkali, containing 52,8 per cent. of fixed air, saturated as much marine acid as 100 grains of marble, which contained 40,7 per cent. of fixed air; now 100 grains of this marble contain, by the analogy formerly given, (45 of fixed air to 55 of lime) 50 grains of lime, by the 2d table, take up 42,2 of real marine acid, and 100 grains of the aerated vol-alkali there mentioned, contain 24 per cent. of mere alkali, and consequently 168 grains of it should contain 40 of mere alkali, which by the above statement would require for saturation 61 of real marine acid. This experiment would have made me doubt of the propriety of the above conclusions, had not Mr. Cavendish expressly stated that his solution of marble was saturate, (and consequently as a saturate solution cannot be obtained without heat, which he did not apply, he must have added an excess of marble, and judged the solution.

solution saturate when no more air was expelled) and on the other hand he tells us, that the alkaline solution contained an excess of acid, and this excess existing in every particle of a large solution must be considerable.

IN the experiment related in my last paper, I stated that 100 grains of aerated vol-alkali were saturated by 246 of marine acid, whose sp. grav. was 1,1355, which appears by the first table to contain 17,5 per cent. real acid, and consequently the quantity in 246 grains was 43 grains; on the other hand, the vol-alkali, containing but 43 per cent. of fixed air, contained, by my actual experiments, only 19,85 grains of mere alkali, and this quantity should take up but 30 of real marine acid. Hence in my former experiments there was an excess of 13 grains of acid, which made the sp. grav. equal to that of the test solution, and thus induced me to think the quantity of sal ammoniac formed greater than it really was.

WENZEL found 168,4 grains of vol-alkali, containing 53,75 per cent. of fixed air, to require 240 grains of his sp. of salt to saturate them, and this quantity of his marine acid we have already seen to contain 55,17 of real acid, and 168,4 of the aerated alkali contained, by the analogy already stated, 41,71 of mere vol-alkali, the sum of both was 96,88; yet having evaporated the solution to dryness, and exposing the residuum to a heat of 212° for four hours, he
found

found it to weigh 110,125 grains, as he knew 55 of these to be acid (or according to him 54), he naturally supposed the remainder to be vol-alkali; hence according to him 100 parts of sal ammoniac thus dried contain 49 parts of acid and 51 of vol-alkali. The difference between us seems to arise from the loss always experienced during evaporation, and if this had not happened, the dry residuum would have amounted to 128 grains; as to the quantity of vol-alkali he had no method of estimating it.

CORNETTE perfectly decomposed 2304 grains of sal ammoniac by an equal quantity of lime, which he slacked after weighing it, examining the residuum, he threw it on a filter, and edulcorated it with repeated effusions of water, and what remained undissolved he found to weigh, when dry, 756 grains, and hence he judged the remainder, viz. 1548 grains to have been dissolved by the acid of the sal ammoniac, and to confirm this conclusion, he precipitated the solution which had passed the filter with a fixed alkali, and drying the precipitate, found it to weigh 1542 grains*; whence it seems to follow, that the acid contained in 2304 of sal ammoniac had dissolved 1542 of lime, whereas, by my calculation, it should dissolve but 1272,46 of lime, for since 100 grains of sal ammoniac contain 42,75 of real marine acid, 2304 should contain 1008; and since by the third table 100 grains real marine acid take up 118,3 of lime, 1008 should take up but 1272,46 of lime.

BUT

* Mem. Par. 1786, p. 533.

BUT the lime I used was pure and perfectly free from fixed air; can that be said of the common lime of Marly, which he employed and does not say he had prepared? Besides, by hisedulcorations, much pure lime must have been dissolved, and have mixed with the solution of muriated lime, and if his alkali were not caustic, the quantity of lime precipitated by it must have been at least partially aerated, and consequently the mere earthy part apparently greater than it would have been if pure. However, as this experiment forms a cumulative proof both of the proportion of acid contained in sal ammoniac, and of the quantity of it taken up by a given weight of lime, I thought it incumbent upon me to repeat it, hence I mixed 50 grains of sal ammoniac with 150 of flacked lime, and heated the mixture in a large glass phial until all the alkali was driven off and the mixture ceased to smell, I then added a sufficient proportion of water, and digested the whole in a gentle heat for some hours, then filtered and edulcorated the mass on the filter, as I judged the solution to contain lime as well as muriated lime, I passed a stream of fixed air into it, which instantly turned it milky, and then filtered it off; the solution now free from lime I precipitated by a solution of an aerated soda, which contained 17 per cent. of fixed air, as much of the solution was requisite as contained 123 grains of soda. The precipitate collected, edulcorated and dried for some hours on the filter, in a heat of 150°, weighed 46,75 grains, though no more could be separated than 41,62, these after ignition weighed 35 grains, some stuck to the
glass

glafs, and 5,25 remained in the filter; 123 grains of the foda gave out 20,91 of fixed air, and, as I afterwards found, kept about a grain of the lime in folution, now 21 grains of fixed air are absorbed by 23,44 of lime, this then was the quantity of lime taken up by the acid contained in 50 grains of fal ammoniac, that is, 21,37 real marine acid, whereas by my calculation, fince 100 grains marine acid take 118,3 of lime, 21,37 fhould take up 25,28, the difference is 1,84 grains, and even this I believe to proceed from the whole of the fal ammoniac not having been decomposed, 19,8 grains of the acid appear to have been taken up by the lime, and about 3,6 of the ammoniac efaped decomposition, this alfo clearly appears by the action of the foda, for 100 grains of this foda contain 22 of mere alkali, then 123 grains of it contains 27; as 100 grains mere mineral alkali take up 73,41 of marine acid, then 27 fhould take up 19,82.

HENCE we fee that in Rigour 100 parts fal ammoniac may be decomposed by 100 parts chalk, for 100 parts chalk generally afford 42 of fixed air, and confequently contain 51,3 of lime, and 100 parts fal ammoniac contains 42,75 real acid, and fince 100 grains real marine acid are faturated by 118,3 of lime, 42,75 of this acid require but 49,57 of earth; but in all fuch cafes the medium of decomposition is always taken in greater quantity than is abfolutely requifite, otherwife the mixture would never be perfect, and in this cafe part of the falt might fublime without decomposition; hence 200 parts chalk are moft commonly ufed,

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though

though 125 are said to be sufficient. *Doffie Elab. laid open* 110, 1 *Labor. in Grofs* 68, in note per *Weigleb.* and in effect 125 grains chalk, at the above rate, would furnish 52 grains of fixed air, which would saturate 24 of vol-alkali, and the ammoniac contains a sufficiency of water.

HENCE also we see how it happens that 100 parts fal ammoniac decomposed by 200 parts chalk frequently afford 89, nay, according to Baumé, even 94 parts aerated vol-alkali, for if there were no loss 125 parts of chalk were sufficient, but then this large quantity of fixed air is expelled, not by the acid of the fal ammoniac, but by the heat applied, as Pellitier de la Sale has noticed, 2 *Pharmacopie de Londres* 427, and on this account magnesia, as it parts with its fixed air much more easily, and contains more water, affords a quantity of aerated vol-alkali, when used as a medium for decomposing fal ammoniac, nearly double that of the fal ammoniac employed. Thus Westrumb from 100 grains of sublimed fal ammoniac and 300 of magnesia obtained 193 grains aerated vol-alkali, 2 *Chy. An.* 1788, p. 15; his magnesia must have contained a very large proportion both of fixed air and water, for he says that 1920 grains of it being calcined left only 600 of earth, *ibid.* 17.

HENCE also, Dolfuz having treated 100 parts fal ammoniac with 125, and even with 200 of chalk, in a glass retort, obtained no more than 50 of aerated vol-alkali; the same thing happened when
he

he used an earthen retort, as he simply heated it to redness, whereas a strong white heat is requisite to expel fixed air from chalk, 2 Crell. Beytr. 199. I believe unpurified sal ammoniac would yield more aerated vol-alkali than the purified, on account of the oil it contains, which affords fixed air. Another certain proof that 125 grains chalk are not acted upon by the acid contained in the 100 parts sal ammoniac, but contribute to the increased quantity of aerated alkali merely by the fixed air expelled from them by heat, is that the residuum contains some calcareous earth which the acid had not attacked, as Richter has observed, 1 Stock. 2 Theile 98 and 99.

SEVERAL important deductions may be deduced from the knowledge of the composition of sal ammoniac, for instance, an easy explanation of its great refrigerating power, &c. which being improper for this place, I omit.

VITRIOLIC AMMONIAC.

100 grains of crystallized vitriolated vol-alkali and 300 dry flaked lime, pneumatically distilled in a pneumatic apparatus and a strong sand heat, Bar. 30,2, Therm. 66°, afforded 78,41 cubic inches of alkaline air, = 14,24 grains.

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FROM

FROM a solution of vitriolated vol-alkali, precipitated by a solution of muriated barytes, 164 grains of ignited baroselenite were obtained, hence the salt contained 54,66 grains real vitriolic acid.

HENCE 100 grains vitriolated vol-alkali contain 14,24 of mere vol-alkali, 54,66 of real acid, and 31,1 of water.

IN my former paper I stated the quantity of vitriolic acid in 100 grains of crystallized vitriolated vol-alkali to be 62,47 standard, = 55,7 real acid, the variation is not considerable, but of the alkali I could not then form a proper estimate.

HENCE 100 parts mere vol-alkali take up 383,8 of real vitriolic acid, and *afford* 702,24 of vitriolated volalkali.

2dly, 100 parts real vitriolic acid should take up 26,05 of mere vol-alkali, and *afford* 182,94 of vitriolated vol-alkali.

ACCORDING to Wenzel, also, 100 parts vitriolic ammoniac contain 58,8 of real acid, hence of all crystallized salts it contains the greatest proportion of this acid, as Glauber does the least.

NITRATED VOL-ALKALI.

FROM 50 grains of crystallized nitrated vol-alkali, mixed with twice its weight of slacked lime, I obtained, in a pneumatic apparatus, 40 cubic inches of alkaline air, Bar. 30,06, Therm. 61°,
by

by the simple heat of a candle; some water also passed, which undoubtedly absorbed some air, a greater heat could not be applied without risking a decomposition of the alkali itself; hence 100 grains of this salt would yield 80 of air, which in these circumstances would weigh 14,52 grains. In another experiment I obtained still less of this air, for 50 grains of this salt afforded only 34,962 cubic inches, the barometer indeed stood higher, namely at 30,26, and the thermometer only at 58.

FINDING this method inadequate to the discovery of the exact quantity of vol-alkali in this salt, I tried the effect of spontaneous evaporation on a mixture of this salt with lime and water, but soon found the quantity evaporated so great that it was very evident it did not proceed from the mere volatilization of the alkaline part, but in a great measure from that of the water also, hence I was obliged to content myself with detecting the proportion of the acid part.

For this purpose I made a solution of 400 grains crystallized nitrous ammoniac, and to this added a small proportion of a solution of tartarin slightly aerated; as the point of saturation could not be ascertained by any test, I added but little of the tartarin, and set the liquor to evaporate in a very gentle heat. The next day I found some crystals of nitre, which I carefully picked out, washed and dried, then added more tartarin to the mother liquor, set it to evaporate and crystallize as before. Thus I proceeded for
several

several days and at last obtained 412 grains crystallized, well dried nitre. Now 412 grains nitre contain, by my account, 181,28 grains real nitrous acid, this quantity therefore existed in 400 grains of the nitrous ammoniac, consequently 100 grains of this salt should contain 45,3 of real nitrous acid.

THERE are however strong reasons to think that this salt contains much larger proportion of acid; for in the first place the salt volatilizes without decomposition with the water that holds it in solution, as Berthollet observed in an experiment I shall presently relate, and consequently it is reasonable to suppose that some escaped this way in my experiment, and moreover nitre is itself in some measure volatile during the evaporation of its solution, and lastly, both Wenzel, Cornette and myself found a larger proportion of acid taken up by vol-alkali during the combination of both.

IN my last paper I stated the proportion of ingredients in nitrous ammoniac at 24 vol-alkali 78,75 standard, which quantity is equivalent to 57,8 grains real acid, but noticed that there was an excess of acid. At present all due corrections made from this experiment, I infer that 100 grains crystallized nitrous ammoniac contain 57 nitrous acid, 23 of vol-alkali and 20 of water.

HENCE 100 grains vol-alkali take up 247,82 of nitrous acid, and should afford 435 of crystallized nitrated vol-alkali, if there were no loss in evaporation or no decomposition.

AND

AND 100 grains nitrous acid should take up 40,35 of vol-alkali, and *afford* 175,44 of ammoniac, if no loss &c.

AN experiment of my own, related in my last paper, seems to contradict these results, for I there stated that 200 grains aerated vol-alkali, which contained 50 per cent. of fixed air, and consequently the whole, 46 of vol-alkali, having been saturated with nitrous acid, to have afforded 296 of nitrated ammoniac, whereas by calculating from the above statements they should afford but 200: but the reason is, that the mass of salt then procured was not wholly crystallized, but contained much of the mother liquor and an excess of acid which increased its weight. The only object I had then in view was to shew that the weight obtained was less than could be expected from the theory I had then formed, for this purpose it was not necessary to push the desiccation very far—a decomposition also took place as will presently be seen.

ACCORDING to Wenzel 240 grains of dry uncrytallized nitrated vol-alkali contain 155,9 of his strongest acid, 77,5 mere vol-alkali and 6,6 water: then 100 grains of this salt should contain 64,95 acid, 32,29 vol-alkali, and 2,76 water. 123 grains of his aerated vol-alkali which contained 53,75 of fixed air, being saturated with nitrous acid, afforded him in one experiment 127 of nitrated vol-alkali, and in another 123; by my calculation, this quantity of vol-alkali should afford 132,6 of the crytallized salt.

CORNETTE saturated 2304 grains of nitrous acid whose sp. grav. was to that of water as 10 to 8, that is, 1,250 (he does not mention the temperature) with 1152 of an aerated vol-alkali extracted from sal ammoniac by a fixed alkali (he does not tell how much air it contained), and evaporating to dryness obtained 1476 of uncrytallized nitrated vol-alkali, Mem. Par. 1783, p. 748.

If the sp. grav. of the acid were taken at 60° it would contain by my table 31,62 per cent. real acid, but if at 10° of Reaumur, as is usual in France, it would contain 32 per cent. the concrete alkali being extracted by a fixed alkali which yields most, cannot be supposed to contain less than 52 per cent. of fixed air, and consequently 24 per cent. of mere vol-alkali, then 2304 grains of his acid contained 737,28 real nitrous acid, and 1152 of the aerated vol-alkali contained 281,48 of mere vol-alkali; and if 737,28 real nitrous acid take up 281,48 of mere vol-alkali, 100 grains of the acid should take up 38,2 nearly of vol-alkali which approaches nearly to my conclusion.

BUT as to the quantities of nitrated vol-alkali the difference is far greater; for if 737,28 grains of real acid saturated with vol-alkali afford 1476 of nitrated vol-alkali, 100 grains of this acid should afford 200 of this salt; whereas by my computation it should afford but 175,44.

THESE discordant results evidently shew that a decomposition takes place in evaporating this salt in a heat even of 80° ; the hydrogen

drogen of the vol-alkali partially decomposes the nitrous acid, and converts it either into nitrous air, which by contact with the atmosphere reforms nitrous acid, is reabsorbed, and attracting more moisture forms the excess of acid and increase of weight which is sometimes found; or the acid is so far decomposed as to become *rudimental nitrous air*, which is the substance Dr. Priestly calls *dephlogisticated nitrous air*, which refusing all combination, flies off and occasions a loss of weight; sometimes both changes take place.

BERTHOLLET * distilled 1152 grains of dry nitrated vol-alkali in a hydro-pneumatic apparatus, consisting of a retort, two enfiladed receivers, and a jar to receive air, 1080 grains passed out of the retort into the receiver, consequently 72 grains only remained in the retort.

THE enfiladed receivers contained 619 grains of a liquor highly acid, and much *rudimental nitrous air* (what Dr. Priestly calls *dephlogisticated nitrous air*) was produced, the weight of this or other air and water, produced and lost, consequently amounted to 461 grains, for $1080 - 619 = 461$.

To discover the contents of the 619 grains of acid liquor he distilled it in a water bath, there remained in the retort 320 grains

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of

* Mem. Par. 1785, 316.]

of ammoniac, which had not been decomposed by the 1st distillation, but had passed with the water into the enfiladed receivers, which proves that much of this salt is volatilized during the evaporation of its solution.

By this 2d distillation an acid liquor passed into the receiver, its weight must have been $619 - 320 = 299$ grains, these 299 grains he saturated with tartarin, the addition of which produced no smell of vol-alkali, consequently no undecomposed vol-alkali remained. He then distilled off the water and found it perfectly pure, there remained in the retort 54 grains of nitre, whence, depending on Bergman's calculation, he supposes the 299 grains of the acid liquor to have contained 18 grains of real nitrous acid, and that the remainder, viz. 281 grains must have been water formed; hence he concludes, 1st, that 760 grains of nitrated ammoniac were decomposed, for $72 + 320 = 392$ escaped during decomposition, and these being subtracted from 1152, leave 760. 2dly, That from this decomposition 281 grs. of water had been produced, and even more, for some was lost, p. 318. All these changes were effected by the 1st distillation.

I SHALL now examine this curious experiment on the grounds of the foregoing theory.

1st,

1st, 760 grains of nitrated vol-alkali contain, by my account, 57 per cent. nitrous acid, 23 per cent. vol-alkali, and 20 per cent. water.

Consequently of acid	433,2
vol-alkali	174,8
water	152,00
	<hr/>
	760

AGAIN, 54 grains nitre contain, by my account, 23,76 real acid, and these, subtracted from 433,2, leave 409,24 to form water and the rudimental nitrous air.

HENCE $760 - 23,76 = 736,24$ grains form the quantity to be accounted for; we must also assign the reason why rudimental nitrous air, and not mere nitrous air, was left.

2dly, Of the 281 grains of *water*, found by Berthollet, 152 pre-existed by my theory, consequently the formation of 129, and of the additional quantity lost, must be accounted for. To effect this we are to observe,

3dly, That according to Berthollet's analysis 100 grains vol-alkali consist of 19,34 of hydrogen, and 80,66 of mephite, consequently that 178,4 grains of vol-alkali contain 33,8 of hydrogen.

4thly, 100 grains water, by the most exact experiment, require for their composition 14,338 grains of hydrogen, consequently 129 grains of water require 18,497 of hydrogen, 9 Ann.

Chy. p. 45 ; consequently 129 grains water require 18,497 of hydrogen, consequently there remained 15,3 grains of hydrogen for the formation of about 100 grains more of water, which were lost.

5th. LAVOSIER assigns to 100 grains of fully oxygenated nitrous acid about 64 of nitrous air and 36 of acidifying oxygen ; but in its common state of oxygenation we may assign it 25 only of superadded oxygen ; and consequently 100 grains of the common acid contain 75 of nitrous air and 25 of acidifying oxygen. Nitrous air itself contains about $\frac{2}{3}$ of its weight of oxygen, and $\frac{1}{3}$ mephite. 1 Lav. Elem. 235, and Mem. Par. 1781.

Now 100 grains water require for their formation 85,662 of oxygen, therefore 229 grains of water would require 196,16 ; but 409 grains nitrous acid, supposing it even fully oxygenated, contain no more than 147,24 of acidifying oxygen, therefore the remainder *v. z.* 48,92 must have been extracted from the nitrous air, and much more, if we suppose the nitrous acid to contain but 25 per cent. of acidifying oxygen ; for then the nitrous acid would supply but 102,25, and consequently 93,91 should be taken from the nitrous air.

Now, according to the experiments of Dr. Priestly and Dieman, if much oxygen be subtracted from nitrous air it will be converted into rudimental nitrous air ; thus this conversion, and the quantity of water found, are adequately accounted for on the theory above laid down.

THE

THE account of the results of this operation may be rendered still clearer by the following table.

1080 grains passed into the receivers at the first distillation, namely,

	Gr.
undecomposed ammoniac	- 320,
undecomposed nitrous acid	- 23,76
water of composition	- 152,
water produced	- 229,
mephite of the vol-alkali	- 141,

Of 409 nitrous acid,
from which its acidify-
ing oxygen, namely,
102,25 grains, were ex-
tracted, there remained
306,95 grains of nitrous
air; and of this, after
the extraction of 93,91
of oxygen, there re-
mained 212,84 of rudi-
mental nitrous air.

rudimental nitrous air	-	212,84
Total	-	1078,60
Loss unaccounted for	-	1,4

1080,0

Remarks

*Remarks on Mr. Richter's Calculation of the Proportion of Ingredients
in Neutral Salts.*

SINCE the publication of my last paper Mr. Richter, an able German Mathematician and natural philosopher, has published an elaborate treatise on the same subject, in which infinite labour and great mathematical ingenuity is displayed; his conclusions, however, differ considerably from mine; least this difference among so many experiments should suggest a doubt concerning the determinations I have endeavoured to establish, I feel myself obliged to investigate the source of this difference, and to shew the inaccuracy of several of his fundamental inductions.

Section 1st.

STOCHYOMETRY, 2 THEILE.

By his first experiment, the foundation of several of his subsequent conclusions, he endeavours to discover the real quantity of calcareous earth in chalk, he found 2400 grains of chalk exposed in an *earthen* vessel to the greatest heat of a wind furnace (how long?) to weigh, when cool, only 1342 grains, therefore 1000 grains of this chalk would weigh 559 grains, and this without farther proof he takes to be the true quantity of lime contained in it.

ON

ON this experiment I remark, that it does not clearly appear that the chalk was thoroughly calcined, but on the contrary there is great reason to think it was not, because chalk has never been known to contain so large a proportion of lime as $\frac{550}{1000}$, it is true, he says, it did not effervesce with acids, but surely it heated and bubbled, and such bubbles are not distinguishable from real effervescence, where the quantity of fixed air is small, but by weighing before and after the addition of an acid, which he does not say he had done.

DR. BLACK found it impossible to calcine any considerable quantity of lime in an *earthen* crucible, but was obliged to use one of black-lead to avoid vitrification, 2 Ed. Essays, 219. Smith found the same difficulty to effect the entire expulsion of fixed air, Differt. de Aere fixo, p. 40, 43. Chalk in general contains no more than 49 or 50 per cent. of fixed air, and the chalk he used, if it was purified, as he mentions in the 2d section, must have contained abundance of moisture; it commonly contains but 41 per cent. of fixed air, and the proportion of earth in such case is only 50 per cent. or $\frac{500}{1000}$, therefore $\frac{500}{1000}$ grains of fixed air remained unexpelled.

Section 3d.

5760 grains of sp. of salt were saturated with 2393 of the aforementioned chalk, and the whole being evaporated to dryness and
heated

heated to thin fusion, weighed 2544 grains, now at the rate he had before laid down, the 2393 grains of chalk contained 1337 of lime, and deducting this from the falited mass, he concludes the remainder, viz. 1207 to have been mere, or what I call real marine acid *. There the error committed in stating the quantity of lime is important, as from this the proportion of real acid in the sp. of salt is deduced, and applied in calculating its proportion in other muriatic salts. If the chalk contained 50 per cent. of lime, as I state it, then 2393 grains of it contained 1196 of lime, and deducting this from the 2544 of falited lime, the remainder, viz. 1348 is the quantity of real muriatic acid contained in that mass, and consequently that which is contained in 5760 grains of his sp. of salt, and 1000 grains of it contained 234.03 nearly, instead of 209, as he states it.

Section 33d.

I PASS to this section, as it is here that the defect of his determination will more clearly appear. In this he tells us, that he saturated 1760 grains of a solution of mild vegetable alkali with 2740 grains of the above mentioned sp. of salt, evaporated and fused the neutral salt thus formed, and found it to weigh 1856 grains, whence, as by his statement, 2740 grains of that sp. of salt contained

* By an error of the press it is stated in the original that 1207, 2544 :: 1000, 1107.

tained 573 of real acid, and this quantity entered into the 1856 grains of neutral salt, it follows that by subtracting 573 from 1856 the remainder will exhibit the weight of the alkali, namely, 1283 grains.

It must be allowed that this is a very indirect and improper method of discovering the real quantity of mild alkali in the alkaline solution, for it comes loaded with the inaccuracies attending the two previous determinations, that of the real quantity of lime, from which that of the marine acid is inferred, and that of the marine acid, from which this last determination is deduced; besides, if any muriated tartarin existed in the alkaline solution, as it often does, it would escape this method and could not be detected.

BUT a more apparent objection lies to it; if 1856 grains of muriated tartarin contain only 573 of real acid, then 100 grains of this salt would contain only 30,86; now if any thing be well proved in my essay, it is assuredly the assertion, that 100 grains of this salt contain nearly 36 of real acid, being confirmed by the experiments on salited silver, and the decomposition of common salt, therefore Richter's determination is erroneous, by allowing to this salt too small a proportion of acid.

BUT if we determine the quantity of alkali in the 5760 grains of alkaline solution by the quantity of real marine acid it was able

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to saturate, calculated as I mentioned in the above experiment on lime; it will be found very exactly; for there I stated that 5760 grains of his sp. of salt contained 1348 of real acid, and consequently 2740 contained 641,25. Now as 36 of acid take up 64 of vegetable alkali, 641,25 take up 1140 of that alkali, and the sum of both *v. z.* 1781, will be the quantity of muriated tartarin thus formed. It is true he found its weight to be 1856 grains, that is 75 grains more than by my calculation, but this excess most probably was caused by the muriated tartarin previously existing in his alkaline solution. His mode of obtaining what he calls a pure alkaline solution renders this highly probable.

To obtain a pure alkali (§ 33) he simply pours cold water on common pot-ash, and leaves them together, frequently agitating them for 24 hours; the solution thus obtained he evaporates to dryness, and then again treats the saline mass with cold water, but with a quantity of it too small to re-dissolve the whole; such was the alkaline solution he employed. Now though much of the neutral salts contained in pot-ash may thus remain undissolved, yet some certainly will be taken up, and among the rest muriated tartarin, which is frequently found in vegetable ashes * and does not require above three * times its weight of water to dissolve it. To this, then, the excess of 75 grains may well be ascribed.

THE justness of this conclusion is still further confirmed by examining his experiment on vitriolated tartarin. He saturated another

* Wiegand. über die Alkalische Salze 98.

ther pound of the alkaline solution with 3647 grains of dilute vitriolic acid, and after evaporation and ignition found the salt to weigh 2090 grains, and as he thinks he has proved the quantity of alkali in 5760 grains of the alkaline solution to be 1283 grains, hence he concludes the quantity of acid in the 2090 grains to be $2090 - 1283 = 807$ grains; if so, vitriolated tartarin should contain but 38,6 grains per cent. of acid, whereas it has been proved to contain much more.—But allowing the quantity of alkali in the pound of alkaline solution to be, as I stated it, 1140 grains, then as 55 parts alkali take up 45 of real vitriolic acid, 1140 will take up 933 of this acid, and the sum of both will be 2073, which differs from 2090 only by 17 grains, owing probably to the muriated tartarin contained in his alkaline solution, which may even have been decomposed by the vitriolic acid. He determined, it is true, the quantity of vitriolic acid by another operation, § 18, but here a material and evident error occurs, as I shall presently shew:

1st, To 8460 grains of vitriolic acid, whose sp. grav. was 1,8553, he added 19200 of water, or, which is the same thing, to 84,6 of the concentrated acid he added 192 of water, and found the sp. grav. of the mixture 1,214.

2dly, He saturated 9075 grains of this dilute acid with 3215 grains of the chalk above-mentioned, and as by his account 1000 parts of that chalk contained 559 of lime, he concluded that

R 2

3215

3215 grains of it contained 1596 of lime. Then having heated the selenite thus formed to a degree sufficient to convert lime-stone into lime, he found it to weigh 3600 grains, and deducting from this weight that of the lime, he found the remainder, *v. z.* 2004 grains to be the weight of the vitriolic acid which was contained in 9075 grains of the dilute acid liquor, and consequently that the 3647 grains of it which he had employed in saturating the alkali in the former experiment contained 806 grains.

HERE, not to repeat with respect to the chalk what I have already suggested, I shall confine myself to a *single* error, because it is manifest:

As 1000 parts chalk (he says) contain 559 of lime, 3215 grains of it should contain 1596, whereas by the rule of proportion it should be 1797,185; then deducting 1797 from 3600, the remainder, *v. z.* 1803, and not 2004, should be the weight of the acid part of the selenite; and 3647 grains of the dilute acid employed in saturating the alkali should contain, by his own account, 722, and not 806 grains. It would ill become me to reproach Mr. Richter with this oversight, as many of such have often escaped my notice in my own calculations, and occasioned me infinite labour in rectifying their numerous spurious consequences.



TABLE

T A B L E II.

Quantity of Real Acid taken up by mere Alkalis and Earths.

100 Parts.	Vitriolic.	Nitrous.	Marine.	Fixed Air.
Tartarin -	82,48	84,96	56,3	105 almost
Soda - -	127,68	135,71	73,41	66,8
Vol-alkali -	383,8	247,82	171	Variable
Barytes -	50	56	31,8	282
Stronthian -	72,41	85,56	46	43,2
Lime -	143	179,5	84,488	81,81
Magnesia -	172,64	210	111,35	200 Fourcroy
Argill - -	150,9			335 nearly Berg.

T A B L E III.

Of the Quantity of Alkalis and Earths taken up by 100 Parts of Real Vitriolic, Nitrous, Muriatic and Carbonic Acids, saturated.

100 Parts	Tartarin.	Soda.	Vol-Alkali.	Barytes.	Stronthian.	Lime.	Magnesia.
Vitriolic	121,48	78,32	26,05	200,	138,	70,	57,92
Nitrous	117,7	73,43	40,35	178,12	116,86	55,7	47,64
Muriatic	177,6	136,2	58,48	314,46	216,21	118,3	89,8
Carbonic	95,1	149,6	— —	354,5	231, +	122,	50,

T A B L E IV.

Quantity of Neutral Salts afforded by 100 Parts of the above-named Acids when saturated with the above-named Bases.

100 Parts	Tartarin.	Soda.	Vol-Alkali.	Barytes.	Stronthian.	Lime.	Magnesia.
Vitriolic	221,48	{ 425 crystallized 178,5 deficcated }	182,94	300	238	{ 170 in a white heat 198 at 170° }	340 crystallized 158 deficcated
Nitrous	227,22	188	175,44			174 well dried, that is, in air	
Marine	277,6	257,2	233,9	{ 487,4 crystallized 454,5 deficcated }	540 crystallized 313,5 deficcated	238 in a red heat	286,2 well dried
Carbonic	232,5	{ 693,5 crystallized 150 deficcated }		454,5	331,7	222,25	200



T A B L E V.

Quantity of Neutral Salt afforded by 100 Parts of different *Bases*, when combined with the Vitriolic, Nitrou, Marine, or Carbonic Acid.

100 Parts with	Vitriolic.	Nitrous.	Marine.	Carbonic Acids.
Tartarin -	182,48	193 +	156,3	244
Soda -	{ 541,1 crystallized 227,4 deficcated }	246,42	188,74	{ 463,3 crystallized 167 deficcated }
Vol-alkali -	702,94	435	400	
Barytes -	150		{ 155,16 crystallized 142,8 deficcated }	382
Stronthian -	172,41		{ 250 crystallized 145 deficcated }	143,16
Lime -	{ 312 dried at 50° 284 dried at 130° 262,8 ignited 243 incandescent }	{ 312 dried at 80° 280 fully deficcated }	200 in a red heat	182
Magnesia -	{ 588,23 crystallized 272,62 deficcated }		321,8 gently but sensibly dried.	400



28
12
15

28
20
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95

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00
35

T A B L

Of the Proportion of Ingredients in the

100 Parts Carbonic.	Basis.	Acid.	Water.	State.
Aerated Tartarin - -	41, - -	43,	16, - -	Crytallized.
Common Salt of Tartarin or Pearl Ash	60, - - -	30,	6 - - -	Dry.
Aerated Soda - - -	21,58 - - -	14,42	64, - - -	Fully crytallized.
Do. - - -	59,86 - - -	40,05	- - -	Deficcated.
Aerated Barytes - -	78, - - -	22,	- - -	Natural or ignited.
Aerated Stronthian - -	69,5 - - -	30,	- - -	Natural or ignited.
Aerated Lime - - -	55, - - -	45,	- - -	Natural if pure, or artifi
Aerated Magnesia - -	25, - - -	50,	25, - - -	Crytallized.
Common Magnesia - -	45, - - -	34,	21, - - -	Dried at 80°.
Aerated-Vol alkali - -	In the Ratio of 6 ^{of Earth} to 13 fixed Air	2	15 5/11 2/11	
<i>Vitriolic.</i>				
Vitriolated Tartarin - -	54,8 - - -	45,2	- - -	Dry.
Glauber - - -	18,48 - - -	23,52	58, - - -	Fully crytallized.
Do. - - -	44, - - -	56,	- - -	Deficcated at 700°.
Vitriolated Vol-alkali - -	14,24 - - -	54,66	31,1 - - -	
Barofelenite - - -	66,66 - - -	33,33	- - -	Natural and pure, artifi
Vitriolated Stronthian - -	58, - - -	42,	- - -	Natural and pure, artifi
Selenite - - -	32, - - -	46,	22, - - -	Dried at 66°.
Do. - - -	35,23 - - -	50,39	14,38 - - -	Dried at 170°.
Do. - - -	38,81 - - -	55,84	5,35 - - -	Ignited.
Do. - - -	41, - - -	59,	- - -	Incandefcent.
Epſom - - -	17, - - -	29,35	53,65 - - -	Fully crytallized.
Do. - - -	36,68 - - -	63,32	- - -	Deficcated.
Allum - - -	12, ignited - - -	17,66	51, of Cryſtal + 19,24 in the Earth	Crytallized.
Do. - - -	63,75 - - -	36,25	- - -	Deficcated at 700°.
<i>Vitriols</i>				
Of Iron - - -	28, 1 of \mathcal{J} = 12, Metal	26,	38, + 8 of Composition -	Crytallized.
Do. - - -	45, - - -	41,93	13,07 - - -	Calcined to Rednets.
Lead - - -	75, Calx = 71 Metal -	23,37	1,63 - - -	
Copper - - -	40 Calx = 30 Metal -	31,	29, - - -	
Zinc - - -	40 Calx = 30 Metal -	20,5	39, - - -	

in the following Saline Compounds :

State.	100 Parts Nitrous.	Bas.	Acid.	Water.	State.
zed.	Nitre -	51,8	44, - -	4,2 of Composition	Dried at 70°.
	Nitrated Soda -	40,58	53,2 i - -	6,21 of Composition	Dried at 400°.
crystallized.	Do. -	42,34	57,55 - -	- - -	Ignited.
ed.	Nitrated Vol-alkali	23,	57, - -	20, - -	
or ignited.	Nitrated Barytes -	57,	32, - -	11, - -	Crystallized.
or ignited.	Nitrated Stronthian	36,21	31,07 - -	32,72 - -	Crystallized.
if pure, or artificial ignited.	Nitrated Lime -	32,	57,44 - -	10,56 - -	Well dried, that is in Air.
zed.	Nitrated Magnesia	22,	46, - -	22, - -	Crystallized.
80°.					
	<i>Muriatic.</i>				
	Muriated Tartarin -	64,	36, - -	- - -	Dried at 80°.
crystallized.	Common Salt -	53,	47, aqueous, 38,88 real	- - -	Dried at 80°.
ed at 700°.	Sal Ammoniac -	- -	- - -	- - -	Crystallized.
	Do. -	25,	42,75 - -	32,25 - -	Sublimed.
and pure, artificial ignited.	Muriated Barytes -	64,	20, - -	16, - -	Crystallized.
and pure, artificial ignited.	Do. -	76,2	23,8 - -	- - -	Deficcated.
66°.	Muriated Stronthian	40,	18, - -	42, - -	Crystallized.
170°.	Do. -	69,	31, - -	- - -	Deficcated.
	Muriated Lime -	50,	42, - -	8, - -	Red hot.
cent.	Muriated Magnesia	31,07	34,59 - -	34,34 - -	Sensibly dry.
crystallized.	Muriated Silver -	75,	16,54 - -	8,46 Oxygen -	Dried at 130°.
ed.	Muriated Lead -	81,77 ♀ h	18,23 - -	In the Calx -	Crystallized.
zed.	Do. -	83, ♀ of h	17, - -	- - -	Deficcated.
ed at 700°.					
zed.					
to Rednefs.					